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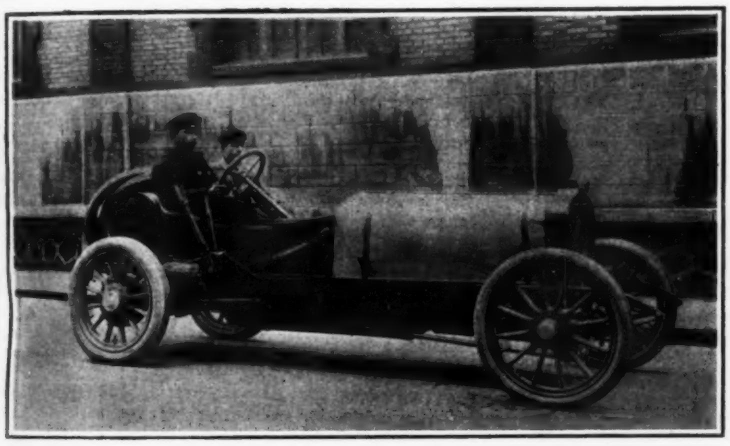
DETAILS OF THE GRAND PRIX RACING CARS.

By the PARIS CORRESPONDENT of SCIENTIFIC AMERICAN.

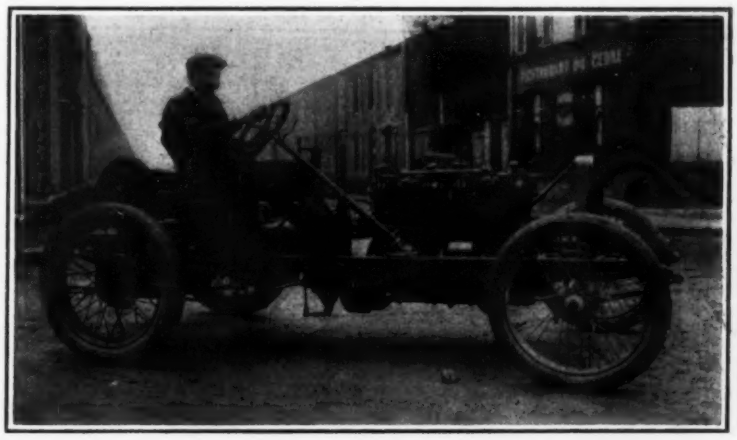
As the winner of the race, the new Renault car naturally claims a share of our attention, and it is of interest not only on this account, but from the fact that it embodies a number of original features which make it depart considerably from the form which we are accustomed to see. The main novelty is the position of the radiator, and instead of being placed as usual in front of the motor, it now lies at about the middle of the chassis and in front of the driver's seat, thus giving the car an original appearance. With the radiator placed in the rear we now have the motor well cleared in front, and it is thus entirely uncovered and has a decided advantage in the way of inspection or repairs, and besides the general appearance of the car, owing to the absence of the radiator in front, is much lighter and more elegant. We are also able to take some of the load off the front axle, and this makes it easier to take the car around the curves of the road, seeing that as the front wheels are lightened up, they now work under better conditions. Besides, the position of the radiator makes it easy to carry out the gravity water-cooling method. If this latter method has not given success in some cases it is because the radiator was not properly designed, and that the gravity principle when applied in the right way can be made a success is well proved by the example of the Renault car. During the race the motor did not give any trouble from heating, and Szisz was not obliged to take on water throughout the whole course.

Thus it will be seen that even with as heavy a motor as the 105-horse-power which was used here, the gravity cooling can be well applied. As will be observed in our engraving, the new radiator is made up of small round copper tubes placed vertically upon a system which somewhat resembles that of a steam engine condenser. The secret of success with this kind of radiator is to find the right relation between the diameter of the tubes and the air current which passed between them, and also to make the set of tubes quite solid so that they will not suffer from the severe shocks which they receive from the car's movement. None of the Renault cars had trouble with the radiators in the present case, and this point is to be well noted, seeing that it is the radiators which are one of the most frequent causes of trouble, and in fact many of the cars had to change their radiators during the race.

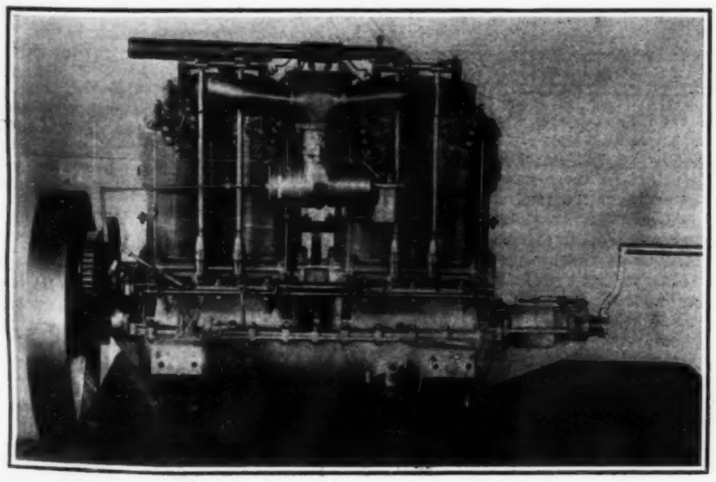
The carbureter is another new point which may be mentioned. It is of the new automatic type which suppresses all heating and gives a great latitude of feed to the motor. This carbureter is based on a very simple principle. A light metal disk is placed in the inlet pipe, and works back and forth so as to regulate the extra supply of air, as it is connected to the air-



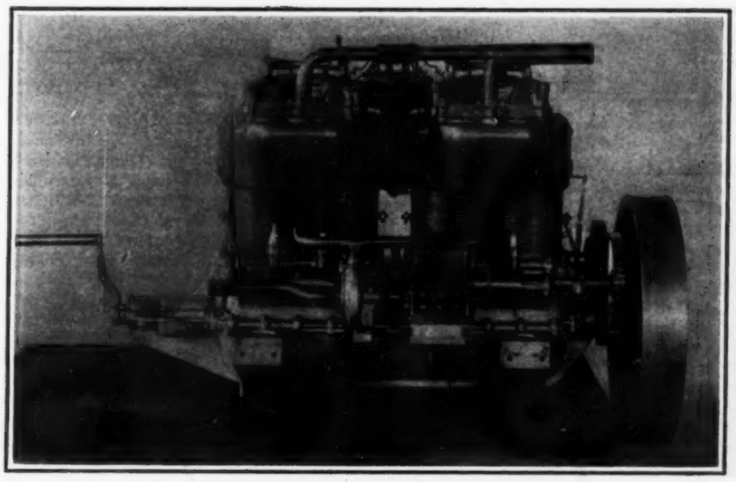
THE CLEMENT CAR.



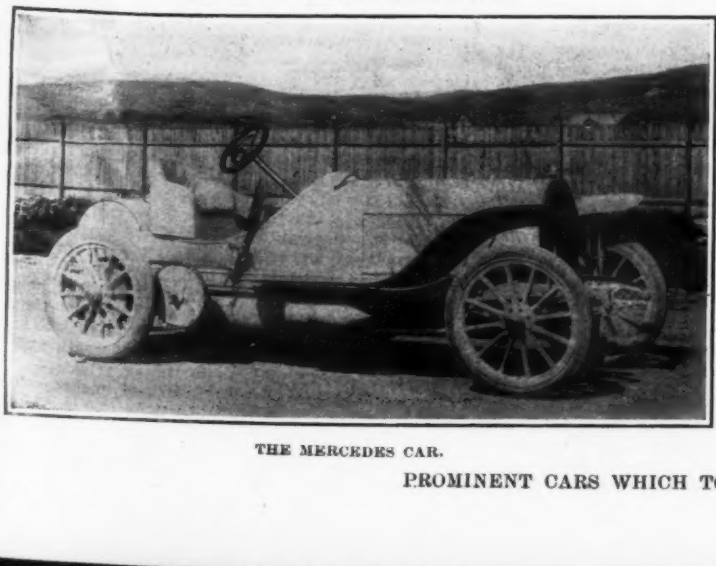
THE DARRACQ CAR.



FRONT VIEW OF MERCEDES MOTOR.



REAR VIEW OF MERCEDES MOTOR.



THE MERCEDES CAR.

LANCIA IN THE ITALIAN FIAT CAR.

PROMINENT CARS WHICH TOOK PART IN THE GRAND PRIX.

entry valve by a lever. A certain space is left between the disk and the inner surface of the pipe so that a certain amount of air can pass by this space, and the latter is just the right amount to give a good carburetion when the motor is running at slow speed. Should the suctions of the motor be spaced somewhat apart, the movement of the disk must be kept regular, so that it will not run wild. The first method was to brake the disk's movement by using a long screw-thread upon the rod of the disk, thus making it take a steady movement, but it was afterward preferred to use a liquid braking system, and in this case the rod is connected with a piston which plunges in the gasoline, acting as a dash-pot. This method makes the carbureter quite automatic and gives an economy of gasoline. No trouble was given by it during the race.

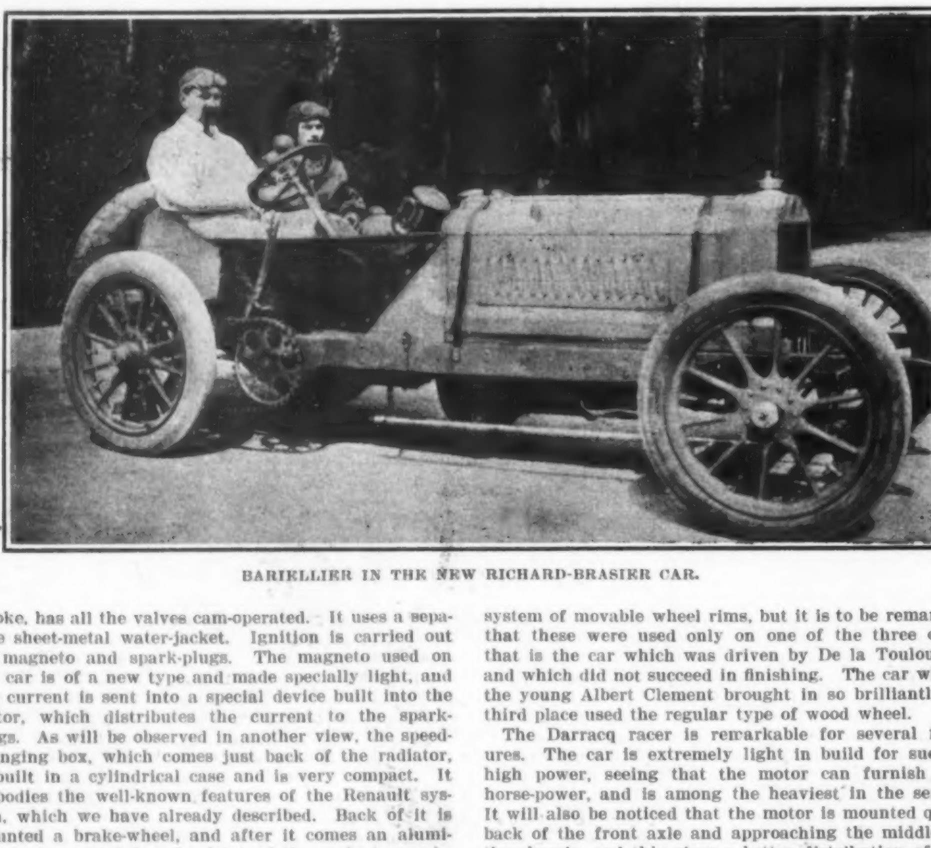
Specially to be remarked in the new racing car is the absence of the differential on the rear axle, and the universal joint rod coming from the front of the car is geared to the axle by a simple pair of bevel gears. This rather unusual method of driving was found a great success in the race, and it is an example of the special modification which the present high speeds are likely to bring about when the design of the car is carefully studied to meet the actual conditions. When running at the great speeds such as we find in the race, the wheels do not always adhere to the soil, but on the contrary they are found to bound up and are often in the air, or at least one of them, so that when one of the rear wheels leaves the ground, the other one has but little propulsive action. In such cases the axle having a differential is actually at a disadvantage, strange as it may seem at first sight, but of course this only applies to the special conditions of high speeds.

The new four-cylinder motor embodies the usual features of the Renault design, and has been built for 105 horse-power, being one of the lightest of the series, as some of the cars had motors as high as 135 horse-power. The motor, having 6.6-inch bore and 6-inch stroke, has all the valves cam-operated. It uses a separate sheet-metal water-jacket. Ignition is carried out by magneto and spark-plugs. The magneto used on the car is of a new type and made specially light, and the current is sent into a special device built into the motor, which distributes the current to the spark-plugs. As will be observed in another view, the speed-changing box, which comes just back of the radiator, is built in a cylindrical case and is very compact. It embodies the well-known features of the Renault system, which we have already described. Back of it is mounted a brake-wheel, and after it comes an aluminium case containing the joint of the main transmission rod which passes to the rear axle. Here will be also noticed the lubricating oil tank. A special pump for the oiling is used in connection with it, and it feeds each of the motor bearings. From thence the oil passes to the crank-heads of the motor. Neither the oil nor the gasoline feed is under pressure.

To finish the description of the Renault car, we may mention the use of a new hydraulic dash-pot device for checking up the jumping of the chassis. It is designed somewhat after the manner of the hydraulic artillery brake, and special care has been given to prevent leaking. The dash-pots have a great advantage of giving a braking effect which is proportional to the speed of the springs' movement, seeing that the braking is carried out by a quantity of liquid passing through a given section. The Renault cars were among those which used the new system of movable wheel rims, of which we shall have occasion to speak further.

The new Lorraine-Dietrich racer carries one of the heaviest motors of the lot. This motor, having two pairs of cylinders with cast water-jackets, is rated at 130 horse-power. A cylinder bore of 7.4 inches and a 6.4-inch stroke is used in this case, and the motor runs at 1,100 revolutions per minute. The spark-break is made inside the cylinders by a mechanical device, and the current is furnished from a magneto of the Simms-Bosch pattern which is driven by gearing and lies at the front of the motor. In the front of the car is mounted a wing type radiator of the Grouvelle-Arquembourg pattern, in which the water circulation is kept up by a turbine pump geared to the motor. At the side of the motor will be noticed the new carbureter which is of the new Lorraine-Dietrich pattern, with vertical air draft. A straight cone-clutch connects the motor with the gear-shifting box. The latter is designed to give four speeds and has a single set of sliding gears. From the differential, a chain drive is used upon the rear axle. One point to be noticed about these cars is that they employ the new Truffault suspension. In the rear of the car is a gasoline tank which works under air pressure and contains some fifty gallons.

As regards the Bayard-Clement racer, we remark that it has a motor of medium size, which gives 125 horse-power. In this case the water-jackets which cover the four vertical cylinders are made of sheet metal. The honeycomb type of radiator is mounted in front of the motor, and it is fed by a turbine pump. Spark-plugs are preferred in this case for the ignition, and a Simms-Bosch magneto supplies the current for these. As to the dimensions of the motor, we find that it has a 6.4-inch bore and 6.4-inch stroke. The speed of running is here 1,350 revolutions per minute. One point which is to be mentioned about the Bayard-Clement car is the use of an all-metal friction clutch. This is of the Hele-Shaw design and the main feature lies in a series of flat disks which lie concentric with each other, so that they can be thrown into contact starting from the center and finishing with the outer disks. In the gear-box, which is provided with three speeds and uses a double set of sliding gears, the back movement is operated by a special lever, which is found to be an advantage. A very efficient oiling system for the whole car is provided by means of a main oil pump worked from the motor, and a set of piping which runs to all the working parts. A universal-joint system of transmission is used to connect the motor with the rear axle. In the rear of the driver's seat is a cylindrical gasoline tank holding 45 gallons. The Clement car was one of the racers which used the system of movable wheel rims, but it is to be remarked that these were used only on one of the three cars, that is the car which was driven by De la Touloubre, and which did not succeed in finishing. The car which the young Albert Clement brought in so brilliantly to third place used the regular type of wood wheel.



BARIELLIER IN THE NEW RICHARD-BRASIER CAR.

The Darracq racer is remarkable for several features. The car is extremely light in build for such a high power, seeing that the motor can furnish 130 horse-power, and is among the heaviest in the series. It will also be noticed that the motor is mounted quite back of the front axle and approaching the middle of the chassis, and this gives a better distribution of the weight. The motor is of a relatively small size for the power it affords, and its four cylinders, mounted in pairs, have a 7.2-inch bore and 6-inch stroke. In front of the motor is a light radiator of the Grouvelle-Arquembourg wing pattern, supplied by a straight wheel pump. The spark-break for the motor is formed inside the cylinders, using magneto current. The Darracq car uses a straight cone clutch combined with the flywheel, followed by a universal-joint rod which connects with a differential on the back axle, but it is to be remarked that the speed-changing mechanism is designed on a different principle from the usual way, and is placed in this case upon the rear axle along with the differential. This new system has been found to work very well, and makes the mechanism of the car somewhat simpler, as it dispenses with the extra gear box, thus saving in weight at the same time. The Darracq 's one of the few cars to use metallic wheels. In front of the driver's seat is mounted a cylindrical tank for the oil, while the water tank is placed in the rear.

This year the Richard-Brasier car has not been modified to any great extent over the leading features which distinguished Thery's car, the winner of last year's race, which we had occasion to describe at that time. We give a general view of this year's car, and may remark that the motor is one of the lightest, as it gives but 105 horse-power, using a 6.6-inch bore and 5.6-inch stroke, and running at 1,200 revolutions per minute. The four vertical cylinders are cast as usual in pairs and are cooled by a wing type radiator. In the new Brasier carbureter which is used on this year's car it is to be remarked that there are two gasoline jets coming from a pair of nozzles in the atomizing chamber which are placed convergent at an angle of 120 degrees. The system of Brasier cone clutch, which was successful in last year's car, has been retained, with a few modifications. The main novelty of the clutch lies in the use of a system of spring locking pins or bolts which come into play to keep the clutch fast together when it is fully thrown on. A three-speed gear box, chain drive and wood wheels are among the other features, also a gasoline tank containing 45 gallons and a Truffault suspension.

The last of the French cars which we shall describe at present is the Panhard and Levassor. In general, we have not many new features to remark about this year's racer, seeing that it adheres to the same general lines as were mentioned in last year's car which ran in the Gordon Bennett cup race. One of the distinguishing features about the Panhard motor is the use of four separate cylinders which are each surrounded with a special copper water-jacket, the joints being brazed with silver. This year the motor, which is among the heaviest, and gives 130 horse-power, has a somewhat larger bore, this being now 7.4 inches with a stroke of 6.8 inches. The speed is now 1,100 revolutions per minute. A new point is the system of dampers which is used to keep down the shocks of the chassis. The dampers are of the form which has been recently designed by Capt. Krebs and use a set of metallic friction plates. The Panhard car used the removable wheel rim this year upon the cars. The carbureter is of the Krebs pattern, with hydraulic regulator.

The Fiat car which brought the Italian team into the front places with Nazzaro and Lancia does not present any special differences over last year's racer, which we already had occasion to describe. This year the motor, which has four cylinders with 7.2-inch bore and 6.4-inch stroke, is the heaviest of the series, as it is rated at 135 horse-power. The Megenet honeycomb radiator is supplied by a turbine pump, and we also note the Hele-Shaw all-metal friction clutch which is about the same as above mentioned. Magneto current is used for the ignition, with mechanical break inside the cylinders. A bucket-chain system of oiling is employed on the motor. Here the gasoline tank, which holds 50 gallons, is worked under pressure. The Truffault suspension is used on the Fiat car. We also show several views of the Mercedes car which made up the German team. Like the former, the general design of the racer has not been changed to any great extent, and on the exterior it is quite the same. The motor, of which the front and rear design will be noticed, has a 7-inch bore and 6-inch stroke and runs at 1,300 revolutions per minute. The Mercedes honeycomb radiator is fed by a turbine pump, and the water tank in the rear of the car holds 55 gallons, being worked under air pressure. An all-metal cylindrical friction clutch, on the Lindsay system, is one of the features to be noted. The gear box contains four speeds, using two sets of sliding gears. A form of damping suspension designed by Jenatzy is applied on the chassis.

SAND FOR MORTAR AND CONCRETE.*

By SANFORD E. THOMPSON.

THE variation in the strength of mortars with different kinds of sand is recognized in the adoption of a standard sand for cement testing. Yet, notwithstanding this long-time recognition of the necessity for uniform sand in order to produce uniform results, still too often in practice while cement must attain a definite tensile strength or be rejected, "sand is sand."

As is frequently the case, if but one kind of sand is available for a job, the question is simply whether this shall be employed with a sufficiently rich mixture to give the required strength, or whether sand shall be transported from a distance at an excessive expense. On the other hand, if two sands are available, an intelligent selection may admit of a material decrease in the percentage of cement without detriment to the resulting mortar or concrete. Many a time, for example, a 1:3 mortar can be made equal or even better in quality than 1:2 mortar made with poor sand and with a consequent saving, we may estimate, of three-quarters of a barrel of cement per cubic yard of mortar. Similarly, in concrete, the substitution of proportions 1:3:6 for 1:2:4 may reduce the quantity of cement nearly one-half barrel per cubic yard of concrete. On a large contract, in such cases, it certainly pays, from the standpoint of the contractor, to incur the expense of transportation of good sand, or else to spend considerable labor on the preparation of the sand nearest at hand. And, indeed, in the final analysis, it pays the cement manufacturer also, because every increment of saving in the cost of mortar or concrete serves to promote the use of concrete as a structural material.

To illustrate the variation in strength, in density, and also in permeability of mortars and concretes made with sands of different qualities, I shall present a series of tests recently made in my own laboratory, adding a few suggestions in regard to practical principles governing the selection of sand and the proportioning of mortar and concrete. First, however, I wish to refer briefly to the causes of variation in strength and to the methods of examining and testing sand.

The primary cause of the difference in strength of mortars having the same proportions of cement, but composed of different sands, lies in the size of the

* Read before the quarterly meeting of the Association of American Portland Cement Manufacturers.

sand, that is, the coarseness and relative coarseness of the grains. There are two principal elements in the strength of mortars, namely, percentage of cement and density, and with the same proportion of cement, the sand producing the densest mortar, that is, the mortar with the smallest percentage of voids, is the strongest.

The voids in mortar are governed by the size of the grains of the sand, in combination with the cement and the water—all three elements must be considered. If the grains of sand are large, the water will have little effect upon the nature of the sand and the cement will serve to fill the voids, making the resulting mortar as dense or rich as the required proportion of cement allows. If the grains of the sand are fine their voids are too small for the cement grains to enter, and the addition of cement forces the sand grains apart instead of simply filling the voids. Besides this, more water will be required in the mixing, and this water will surround and coat the fine particles, still further increasing the bulk and consequently the voids.

On the other hand, if the finer sand grains, taken with the cement and water, are insufficient to fill the voids, the mortar or concrete will be coarse or harsh.

It is thus evident that the sizes of the sand particles should vary with the proportions of cement to sand in the mortar or concrete, a lean mortar requiring more very fine sand than a rich one to assist the cement in filling the voids and thus increasing the density.

While the shape of the grains of sand also has certain influence upon the density, it is usually so slight as to be negligible.

Cleanness of sand is usually a function of the size, because in most cases the dirt is generally nothing but fine mineral matter, but apparently the impurities may sometimes be of such nature to affect the cement chemically. I have known several cases where the failure of concrete to set up for a very long period has been traced directly to the quality of the sand, but I have never yet heard an entirely satisfactory explanation of the causes of this retarding influence. This is an important and interesting point, and I hope someone present can throw more light upon it. It would sometimes appear that the trouble is due to mechanical rather than to chemical causes, the particles of loam or clay in the sand being so extremely fine that the water of the mixture is retained hygroscopically, and thus retards the setting.

In the selection of sand the most common tests are those for weight and voids, but for two reasons these produce misleading results. First, the tests with dry materials, as I have already indicated, will not necessarily correspond to and predicate the effect of the same materials when mixed into a mortar. Second, the difficulty of obtaining uniform conditions with different sands prevents accurate results. For example, a very fine sand, with grains of uniform size, when dry will have very nearly the same percentage of voids as a coarse sand with grains of uniform size, but with moisture as found in the natural bank the conditions are very different, the fine sand being lighter in weight and having a much larger percentage of voids than the coarse, and, furthermore, the weight and voids vary with the percentage of moisture. Yet, as a general rule, we may say that the heaviest sand and the one with the fewest voids is the best, but this is by no means an entirely reliable guide. It is a simple matter to determine the percentage of voids in a sand. The specific gravity of most sand ranges from 2.64 to 2.70, and by first determining the moisture and correcting for this, the voids may be calculated from the weight of a unit volume. But what shall be the condition of the sand when testing the voids? Shall it be dry or moist, loose or shaken, measured in a small measure or in a large one? Every one of these variations will give a different percentage of voids, and if we make use of the void determination to fix the proportions of cement to sand, the same sand may be readily shown to require either 1:2 or 1:3 proportions, or any ratio between the two, according to the condition of the sand and the method of handling it.

If, then, we discard the void test of sand because of its unreliability, what means shall we use for comparing the quality of different sands?

There are three methods of testing sand which will give satisfactory results under proper conditions:

(1) Actual tests of strength of different mortars or concretes made with the sands under consideration;

(2) Determination of percentages of the different sized grains by sieve separation;

(3) Volumetric tests of the mortars or concretes made with the different sands, for determination of yield and density.

Tests of strength require time for the specimens to harden, and are subject to the variations incidental to mixing and molding.

It is probable that a direct examination of the sizes of the sand and other aggregate by screening a sample and then plotting curves of percentages passing will eventually prove to be the correct method to follow. However, as yet our records are too few and our knowledge of the laws of mixtures and the effect of water upon the different sized grains too limited to depend upon this alone to give positive indications of comparative values of different sands.

The volumetric or density test, which consists in determining the volume or yield of any mortar, I consider one of the best methods of testing sand. Using this method, one works with materials in the same conditions as in practice, that is, in the form of mortar. Different sands can be compared using the same proportion of cement, and the density with different proportions of cement to sand may be studied, while, in fact, even the approximate comparative strength of the different mortars may be closely estimated.

This test, as made in my laboratory, is a modification of that employed by Mr. R. Feret, the eminent French authority, and the apparatus is similar to that adopted in recent tests for the New York Aqueduct Commission at Jerome Park Reservoir. The cement and sand are weighed and mixed in the required proportions, and sufficient water added to make a mortar of about the consistency used by a stone mason. This is introduced into a 250 cubic centimeter graduate, little by little, slightly compacted, and, after setting for about an hour, the surplus water is poured off, and the volume is read on the scale. In general, if two sands are to be compared for use in any given proportions, the sand which produces a mixture of smallest volume will also produce a mortar of greatest strength. If the two sands vary appreciably in specific gravity, this must be corrected for when weighing them, so that the sum of the volumes of the sand particles will be the same in each case. The appearance of the mortar in mixing and placing also provides indications of the quality of the sand. It should work smooth and be reasonably free from air bubbles, with only a slight excess of fine material on the surface of the mortar in the graduate. For complete study of the sand, it is necessary also to calculate the density of the mortar and the absolute volumes of the cement and sand.

The density test is applicable either to natural or to artificial sands. Just how far it may be used for comparing the value of a natural sand with that of an artificial sand, like broken stone screenings, has not yet been thoroughly investigated.

The series of tests to which I have already referred shows the effect of the fineness of sand upon the strength of mortar and illustrates the practical use of the tests for density. A few tests of the permeability of concrete were also made with the cement and sand in the same proportions as in the volumetric and strength tests.

Natural sands were selected so as to make the results as practicable as possible, although there would have been even greater variation if the sands had been prepared by artificial screening. The three sands were taken from the same bank, and may be designated for convenience as No. 1, No. 2, and No. 3.

No. 1, coarse sand, was the run of the bank, including all material finer than ¼ inch diameter.

No. 2, fine sand, was taken from a layer in the same bank.

No. 3, very fine sand, was taken from another layer in the bank.

Size of Sieve.	Per cent passing. No. 1 sand.	No. 2 sand.	No. 3 sand.
No. ¼-inch	100	...	...
No. 5-inch	88	...	...
No. 12-inch	77	100	100
No. 40-inch	32	84	96
No. 200-inch	3	6	27

The sieves which I have used in this table, No. 5, No. 12, No. 40, and No. 200—the numbers corresponding in each case to the meshes per linear inch—correspond closely to those adopted by Mr. Feret in France for separating sand, with the exception of No. 200, which is required for determining the amount of dust, and in most cases these are sufficient to give an excellent idea of the composition of a sand. With these screens the maximum size of sand grains as distinguished from gravel are those which just pass a No. 5 sieve and measure slightly over ¼ inch diameter.

The gage of the wire in the wire cloth appreciably affects the size of the opening and consequently the size of the sand grains passing. The wire cloth which I employ, sometimes called market size, is as follows:

Commercial No. of sieve.	Meshes per linear in.	Gage of wire.	Width of opening inches.
5	5	19	.1600
12	12	24	.0583
40	40	33	.0148
200	200	..	.0030

As is usually the case, the fine sands retained the largest percentages of moisture, the coarse sand as it came from the bank having 4.2 per cent moisture by weight, the fine sand 5.6 per cent, and the very fine sand 7.3 per cent moisture.

I have referred to the variations incident to void tests of sand. I cannot better illustrate this than by showing the results of void tests made upon the three sands employed in these experiments.

Weight and Voids in Moist and Dry Sand under Different Conditions of Compacting.

	Coarse Sand. No. 1.	Fine Sand. No. 2.	Very Fine Sand. No. 3.
Weight per cubic foot with moisture—			
Moist and loose......	79	67	65
Moist and shaken....	97	84	82
Weight per cubic foot, dry—			
Dry and loose........	100	92	90
Dry and shaken......	104	98	97
Percentages of Voids in Moist Sand.	No. 1.	No. 2.	No. 3.
Air voids—			
Moist and loose......	50	56	57
Total voids, air and moisture—			
Moist and loose......	53	62	63
Air voids—			
Moist and shaken....	38	45	46
Total voids, air and moisture—			
Moist and shaken....	42	52	53

Percentages of Voids in Dry Sand.

	No. 1.	No. 2.	No. 3.
Dry and loose.......	39	44	45
Dry and shaken.....	37	41	41

Notice the extreme variation in the percentages of voids in the same sand. Thus, the coarse sand, No. 1, ranges from 53 per cent total voids if measured loose and moist, to 37 per cent measured dry and shaken. The finest sand ranges under similar conditions from 63 per cent to 41 per cent. There is, as you see, a very much greater variation in the same sand, due to moisture and different methods of compacting, than between two different sands under the same conditions. For example, in the laboratory the sand is generally handled dry, and the voids in the coarse sand, No. 1, when measured dry and shaken, are 37 per cent while the voids in No. 3, the finest sand, are 41 per cent, a difference of only 4. If measured loose the difference is but 6. Yet the coarse sand, No. 1, produced a mortar which at the age of seven days was more than double the strength of the mortar with fine sand mixed with cement in the same proportions. Or, taken in another way, in order to attain the strength of a 1:3 mortar made with the coarse sand, it would be necessary to mix the cement with the fine sand in proportions 1:1¾. Can we place much reliance on void tests of sand when different conditions will produce such wide variations in weight and voids?

For the volumetric or density tests with the three sands, and also for the series of 2-inch cubes which were tested in compression, the proportions selected were approximately 1:3 by volume, which corresponded to 1:2.6 by exact weight. These proportions were adopted in order to correspond to the proportions 1:3:6 in the permeability tests, which form a part of the same series.

The densities of the three mortars were found to be 0.689 for the mortar of coarse, No. 1, sand; 0.620 for the fine, No. 2, sand, and 0.600 for the very fine, No. 3, sand. That is, the total air plus water in the three mixtures was 31 per cent for the coarse sand, 38 per cent for the fine sand, and 40 per cent for the very fine sand. These percentages represent the actual porosity of the mortars when fresh. The chemical combination of the cement and a small portion of the water reduces the porosity slightly with age, but for density tests the fresh mortar alone is considered. The mortar of coarse sand with its 0.689 density, or 31 per cent air plus water voids, represents a good average mortar.

Two-inch cubes were next made with mortar in the same proportions, using the three sizes of sand, and these were broken at the age of seven days. The resulting strengths averaged 714 pounds per square inch for the mortar with coarse sand, 405 pounds per square inch for the mortar of fine sand, and 330 pounds per square inch for the mortar of very fine sand, thus showing the coarse sand to give more than double the strength of the fine when mixed with cement in the same given proportions.

(To be continued.)

THE TIME OF DISCHARGE IN A CROOKES TUBE.

AN interesting account of experiments carried on to determine the duration of discharge in a Crookes tube is given by A. Broca and Turchini in Comptes Rendus. Following a criticism of the method of Brunhes, the authors point out that this method can give no definite conclusions relating to the time for which the discharge lasts.

A study of the phosphorescence of the glass of the tube by means of a revolving mirror shows that it lasts for a long time, and probably the fluorescence of the platinocyanide exhibits a similar phenomenon. The authors' method consisted in photographing (on specially sensitive plates) a little spark of 5 to 6 millimeters introduced into the circuit with the tube and a Villard turbine-interrupter. The image of the spark was thrown onto the plate by a mirror, whose radius of curvature was 1 meter and which was attached to the axis of the interrupter. This latter turned at the rate of five revolutions a second. The images obtained were extremely feeble, on account of the feeble light of the spark, but sufficiently strong to permit of measurements being made. The results were the same using blunt points of Fe, Al, or Mg. In all cases the plates show a sharp beginning of the discharge, which remains relatively strong for 0.00025 second, when it becomes much more feeble, and terminates asymptotically at the end of about 0.0008 second. This time differs from that obtained electrically (0.0005 second), but is of the same order of magnitude. Probable reasons for this are assigned. These results correspond with the condition of the pure cathode discharge. For tubes of less than a 10-centimeter equivalent spark the same form of discharge is obtained, but there is an elongation proportional to the time. The peculiarities of the discharge can be attributed to the ionization of the sparks. The results point to the existence of a time of discharge characteristic of the state of the tube.

Varnish for Straw Objects.—Mix and dissolve in 800 parts of 95 per cent alcohol, 450 parts of soft Manila copal, clear and in pieces, 65 parts of sandarac, 7.5 parts of camphor, and 40 parts of Venice turpentine. To secure elasticity for the varnish it is well to add a few drops of castor oil, not more than 20 drops per half liter of varnish.—Les Corps Gras Industriels.

HIGH-SPEED MOTOR BOATS.*

By JAMES A. SMITH.

ALTHOUGH the high-speed motor boat has claimed a considerable amount of attention during the last two years, it is of very recent introduction, if we except the high-speed steam launches and the early torpedo boats of twenty to thirty years ago.

This paper concerns itself mainly with the modern types of high-speed launches which have been rendered possible by the developments in internal-combustion motors since the present century opened.

It is, of course, well known that such firms as Messrs. Thornycroft were building in the seventies and eighties powerful steam launches having a form of hull which has served as a basis on which the designers of modern motor launches have worked, but it was not until within the last three years that it became possible to install motors of 100, 200, and even 300 actual horse-power in boats having a total displacement of less than two tons. Except for the fast steam launches referred to above, there was no gradual development of the modern motor boat during a long period of years, as has been usual in most other branches of engineering; so that designers have been, as it were, suddenly confronted with the problem of producing safe and seaworthy designs for very high powers, with practically no data upon which to work. The large number of fast launches now in existence which fulfill these conditions is a proof that the problem has been attacked and solved in a satisfactory manner, so that even at this early date it is interesting to recall the fears with which hull designers were beset so recently as three years ago. It was then felt that a 2-foot propeller revolving at the rate of seventeen to twenty revolutions per second would have a tendency to upset a very light and narrow hull, also that such hulls would inevitably drown themselves in anything of a seaway, or that they would be dangerous and unmanageable under the helm; and, in brief, that they were so far in advance of shipbuilding practice that they represented an impracticable problem. Such fears have proved to be without foundation.

In this country the first motor launches commenced to appear about eighteen years ago. The earliest successful motor launch appears to have been built in 1888, and was fitted with a Priestman engine. The launch "Peregrine" was built by Messrs. Summers & Payne fifteen and one-half years ago; this launch is still in perfect order, with the original engines, as are also the launches "Flyaway" and "Phœbe," built by the same firm in 1895, the latter being in constant use as a yard tender. These three launches are fitted with Daimler motors of an early type and of small power. The "Motive" was built in 1897, and had the first two-stroke cycle engine used in this country of 1½ horse-power. The Motoring Annual for 1905 gives two interesting illustrations of early motor launches, both of which are fitted with Lanchester motors. The first was built in 1895, and was a boat of the Thames punt type, fitted with a sternwheel; she was used for experimental purposes, and ran at a speed of about 5 miles an hour. The second represents a very pretty little boat designed by Mr. F. W. Lanchester in 1897; she is 28 feet in length, and is fitted with an 8-horse-power engine, which drives her at a speed of about 9 miles an hour; this boat has been in constant service until the present date. The "Vitesse" was the first speed motor launch to be built in this country; she is a launch of a river type, and ran at a speed of about 14 miles an hour.

The first serious attempt to produce a high-speed motor launch in this country was made by Mr. S. F. Edge in 1902. This highly successful boat was designed by Mr. Linton Hope, and represented an important advance on anything previously attempted, a speed of 19 knots being attained in fairly smooth water, with 66-rated motor-power. At the same time a large development in high-speed motor launches took place in France, although no boats of any note were produced there until 1903, when Mr. Thubron's "Trèfle-à-Quatre" was built; she was 33 feet long and had a motor of 85 horse-power. These two boats proved what could be done, and since then the development has been very great.

RULES AFFECTING THE DESIGN OF MOTOR BOATS.

No sooner had the practicability of the marine motor been proved than it was recognized as a suitable propelling agency for light river launches, yachts' tenders, ferryboats, speed cruising boats, and boats for various other pleasure and commercial purposes. A new and interesting sport had been introduced, and many people had such launches built almost entirely for racing purposes. In 1902 it was felt that the sport should be properly governed, and the governing body in this country, the Marine Motor Association, was founded in that year.

In the United States, where the natural facilities for the use of motor boats are many times greater than in this country, the governing body, the American Power-Boat Association, was formed at the same time.

In France in the same year the Automobile Club de France undertook the management of the sport, as did also the Yacht Club de France; while in Germany in the following year the Deutscher Automobile Club provided suitable legislation.

The various racing rules are outside the scope of this paper, but we may consider some of the rules which have had a bearing on the design and construction of the boats themselves. The boats naturally fell at once into two classes.

1. Racers, upon the design of which none of the governing bodies have imposed any other restriction than that of length.

2. The restricted classes, for which rules have been provided governing beam, freeboard, life-saving appliances, and, latterly, horse-power.

The length of the high-powered racing classes has been practically fixed at 40 feet, or 12 meters in the case of French boats, this length being limited by European railway facilities, such boats being usually taken by rail from one place to another for racing purposes. The beam and freeboard of these boats have naturally been reduced as much as possible, but it has been found that for powers over 100 horse-power a minimum beam of about 5 feet, or eight beams in the length, is necessary to provide sufficient stability under helm, and to give sufficiency of bearing aft. With the object of saving weight, many of the racing boats have had their freeboard reduced to an unwise extent, but the small advantage in displacement gained thereby does not at all compensate for the discomfort and danger entailed.

In the beginning the Marine Motor Association assumed that the restricted classes should be specially legislated for, so as to encourage healthy and safe types of boats; and it was rightly thought that the kind of boat required for the many duties of a yacht's launch or tender was the type which ought to be developed. Their restricted classes were, therefore, described as "yacht's launches," and a maximum beam-length ratio was fixed, varying from 3.4 for the smallest classes to 5.2 for boats 30 feet in length, the minimum freeboard being fixed at 25 per cent of the minimum beam. Within these limits safe and comfortable boats can be designed, which may be depended upon to possess sufficient stability and reserve of buoyancy, even in a heavy seaway. With the object of putting a premium on displacement, and indirectly on scantlings, the association devised a rating rule in which the area of greatest immersed cross-section is a divisor, the rule at present being:

$$\frac{(\text{Motive Power})^2}{\text{Area of immersed midship section in square feet} + \sqrt{\text{Length}^2 \text{ over all in feet}}} = \text{Rating for time allowance}$$

so that boats of heavy build gain a considerable advantage when racing under time allowance. It will also be observed that high powers are not favored in the restricted classes. More recent legislation restricts the power of these boats to 3.5 horse-power per ton (Thames measurement).

The following are particulars of two representative boats built to this rule, before the power restriction came into force, and it is also to be noted that both these boats are within the limits of the French restrictions:

	"Takumono."	"Quicksilver."
Length over all	21 ft. 4 in.	30 ft.
Breadth over planking	4 ft. 10 in.	5 ft. 10 in.
Draft amidships	11 in.	11 in.
Draft, extreme, at propeller	1 ft. 8 in.	2 ft.
Motor-power by M. M. A. Rule	12.6	39
Weight of hull department complete	800 lbs.	1500 lbs.
Weight of machinery department complete; tank full	590 lbs.	1300 lbs.
Area of midship section	2.72 sq. ft.	3.06 sq. ft.
Speed, light, with crew only	12.8 knots	18.2 knots.
Revolutions	1000	900
Load at rule freeboard; deadweight	830 lbs.	600 lbs.
Load displacement	0.99 ton	1.52 tons.

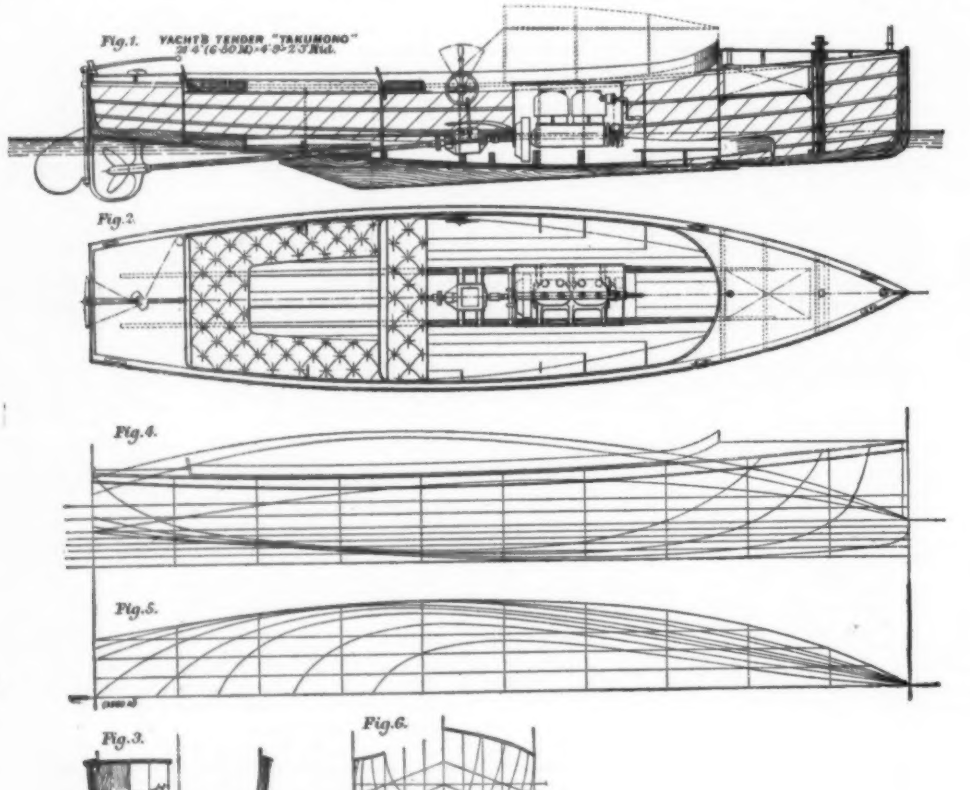
The lines and construction plans of these two boats are appended (Figs. 1 to 6 and Figs. 7 to 10).

The rules adopted by the various foreign governing bodies for restricted or "cruising" boats have been designed with the same objects in view; and there are now many hundreds of such boats in actual use, the number also increasing at a rate which shows no diminution.

VARIOUS CONSIDERATIONS IN DESIGN AND CONSTRUCTION.

Reverting to the early types of motor-boats, it will be seen that they do not differ in form in any marked degree from the ordinary types then in use. Although the electric launch came greatly into favor during the last decade, the weight of machinery per horse-power was comparatively so high that special forms of hull were not found to be necessary, so that the majority of these boats are found to be of what we may call the ordinary ship form, with long, straight keels, and either a transom or canoe stern or long counter. Soon after the introduction, however, of the internal-combustion motor the speed-length ratio rose very rapidly, and a short experience was sufficient to prove that the ordinary ship form was unsuitable. The difference between the water pressures on the fore and after bodies caused such launches to trim so much by the stern when under way that they were not only uncomfortable, but dangerous; consequently the plan was adopted of cutting away all the deadwood aft, and leaving the run of a practically flat section. In many cases this flattening and widening of the after-body sections has been carried to extremes, probably as the result of some confusion between the causes and the effects of high speeds. This form of after-body is common to nearly all high-speed motor-launches, and for such vessels it has proved to be satisfactory for sea work, providing as it does a large amount of surface and initial stability, and tending to counteract the "throw-over" of the screw in a narrow-beam boat of high power. It has also been found that a boat of this form, in the case of a break-down of machinery, behaves well in the trough of a sea, keeping practically normal to the wave-surface owing to its flat form and light displacement, and that it ships very little water, provided it is left to find its own conditions.

The amount of flat-bearing surface required to prevent excessive change of trim need not be considered until the ratio of speed to $\sqrt{\text{length}}$ exceeds unity. The ratio in high-speed motor launches is usually in the vicinity of 3, sometimes exceeding 4, and here a minimum bearing surface of about 40 per cent of the area of the load-water plane should be provided. Generally speaking, the form of this bearing surface is of more importance than its extent, as boats which have been designed for one power have afterward had their motors replaced by others more than twice as powerful, without showing excessive change of trim



HIGH-SPEED MOTOR BOATS.

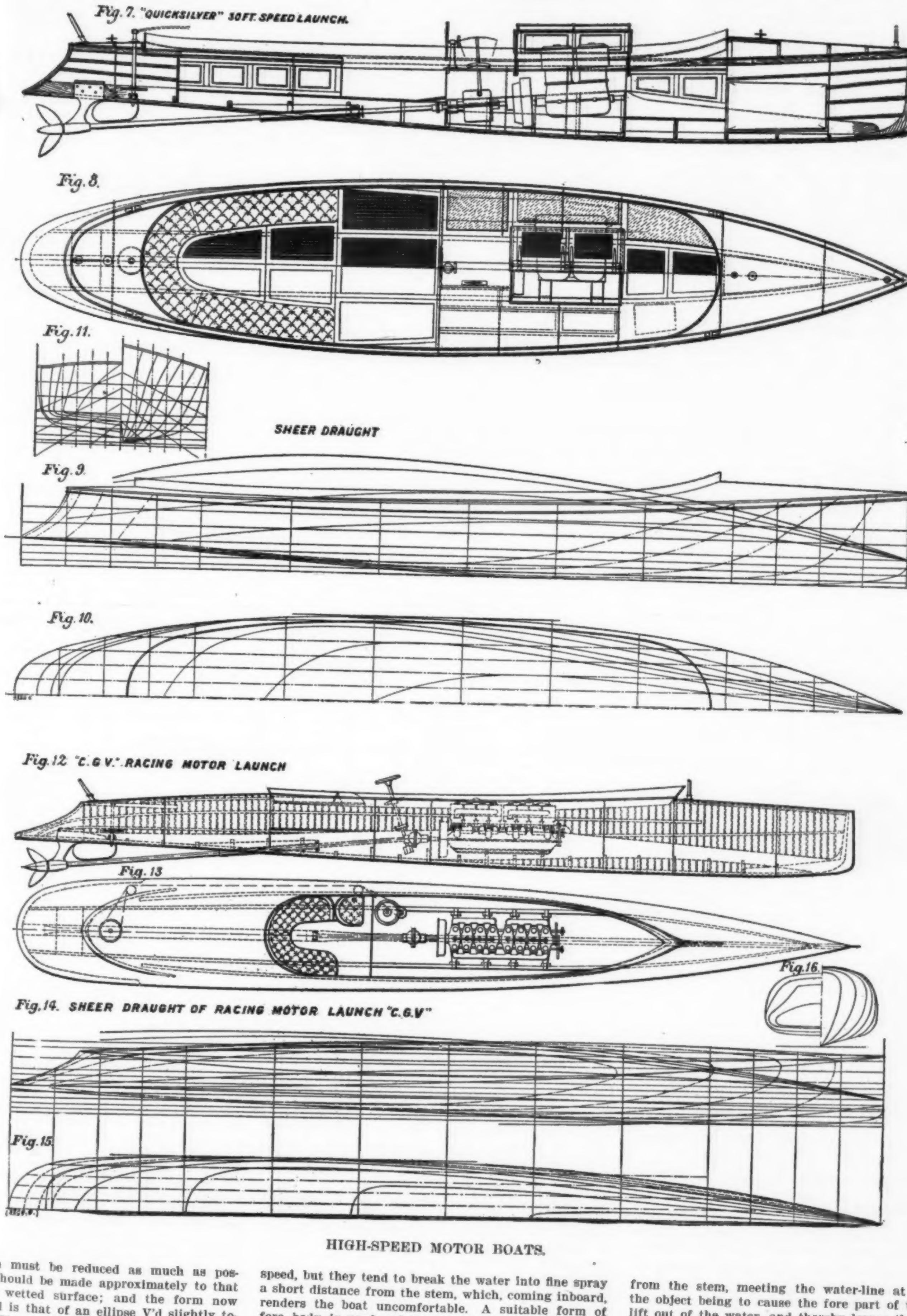
* Paper read before the Institute of Naval Architects.

under way. Other forms of run have been tried, varying between a V section and a tunneled section, but the former, unless carefully wrought out, tends to produce a boat which will heel considerably when the helm is put over; while the latter, although it permits the shaft to be fitted with less rake, is apt to interfere seriously with the free run of the stream lines.

Many forms of midship section have been tried, including sections of an almost triangular shape, flat sections with slightly rounded bilges, and sections of an elliptical form. As the midship section affects the form of the lines in a great part of both bodies, and as V sections, forming, with the after-body, the double wedge, or "all-entrance-and-all-run" form of lines. This form is good in theory, but does not work well in practice, as a short, high-powered boat, built strictly on these lines, would bury itself too much when among waves; and it is also difficult to see what would be lost by cutting off the whole of the deep forefoot, thereby lessening the wetted surface, and avoiding panting and vibration forward. When this is done, the theoretical double wedge no longer exists.

Shallow U-shaped sections forward have been frequently used, giving good results in the matter of ly a matter of individual taste, and, with the light scantlings usually employed, it is possible to form the upper body, and particularly the stern, into almost any desired form.

Other forms of under-water body have been tried, including straight-line boats with perfectly flat bottoms, which are easy to build, but possess no other advantages. In "Napier II.," designed and built by Messrs. Yarrow, a new form of hull has been adopted, consisting of an after-body of usual form, a flat midship section with slightly rounded bilges, and an inclined plane forward from about a third of the length



HIGH-SPEED MOTOR BOATS.

the skin friction must be reduced as much as possible, a section should be made approximately to that giving the least wetted surface; and the form now generally adopted is that of an ellipse V'd slightly toward the keel. This form lends itself to a good type both of after-body and fore-body, permits of an easy angle of entrance of the water lines, and of a suitable form of sectional area curve. Perhaps the best example of this form of midship section is that of "Trèfle-à-Quatre." As to the fore-body, some designers have recommended that it should be made up of sharp speed, but they tend to break the water into fine spray a short distance from the stem, which, coming inboard, renders the boat uncomfortable. A suitable form of fore body is produced by the adoption of a compromise between the very sharp V section and the U section.

The form of sectional area curve is not of great moment in ordinary well-designed boats; for those who prefer it, a curve of versed sines and trochoids will give as good results as any other.

The shape of the boat above the water-line is large- from the stem, meeting the water-line at the stem; the object being to cause the fore part of the boat to lift out of the water, and thereby lessen the skin and wave resistances. Very satisfactory speed results have been obtained from this boat, and a second boat of similar design—"Yarrow-Napier"—has been built. Although it is difficult, from a mechanical standpoint, to estimate the advantages to be gained by the adoption of this form, there appears to be little doubt that the "skating" effect has been achieved.

The particulars of "Napier II." are as follows;

Length over all	40 ft.
Beam extreme	5 ft.
Draft amidships	9 in.
Weight of hull department complete	3,300 lbs.
Weight of machinery department complete; tank full	3,400 lbs.
Total displacement with crew of three	3.19 tons.
Motor power by M. M. A. rule	146

The lines and construction plans of "Napier II." are appended. (Figs. 19 to 27.)

Following on the experience gained with "Napier II.," Messrs. Yarrow have just completed a 60-foot second-class torpedo-boat, "1176," built of steel, and fitted with five 75-horse-power Yarrow-Napier motors. A form of under-water body similar to that of "Napier II." and "Yarrow-Napier" has been adopted, and it will be seen from the pictures (not reproduced) that the boat travels very lightly over the water, with, judging from the waves and wake, very little wave-resistance. Comparing this boat with a second-class steam torpedo boat, the weights and speeds are:

	Second-class Steam Torpedo-Boat.	"1176."
Displacement	11 tons.	8 tons.
Weight of machinery department, steam up	5.25 tons.	3 tons.
Indicated horse-power	300	375
Average speed, smooth water	20 knots.	25 knots.

The sheer draft of "Napier," a 12-meter launch (Figs. 28 and 29), built by Messrs. Saunders last year, illustrates a type of underwater body designed on exactly opposite lines to the Yarrow boats. The fore body consists of V sections, passing into a midship section with a hollow bilge, the hollow increasing aft amidships until at about one-fourth of the length from the stern the vertical under-water body disappears, leaving flat sections aft of this of the usual motor-boat form. The after part of the vertical body, therefore, appears not unlike one of the built-out shaft bosses of a twin-screw steamer. Very fine entrance lines are obtained; and, although the boat has more wetted surface than one of usual form, she has very little wave-making resistance. Constructional advantages are also gained, the long motor-bearers being dispensed with, while the shaft may be fitted almost horizontally.

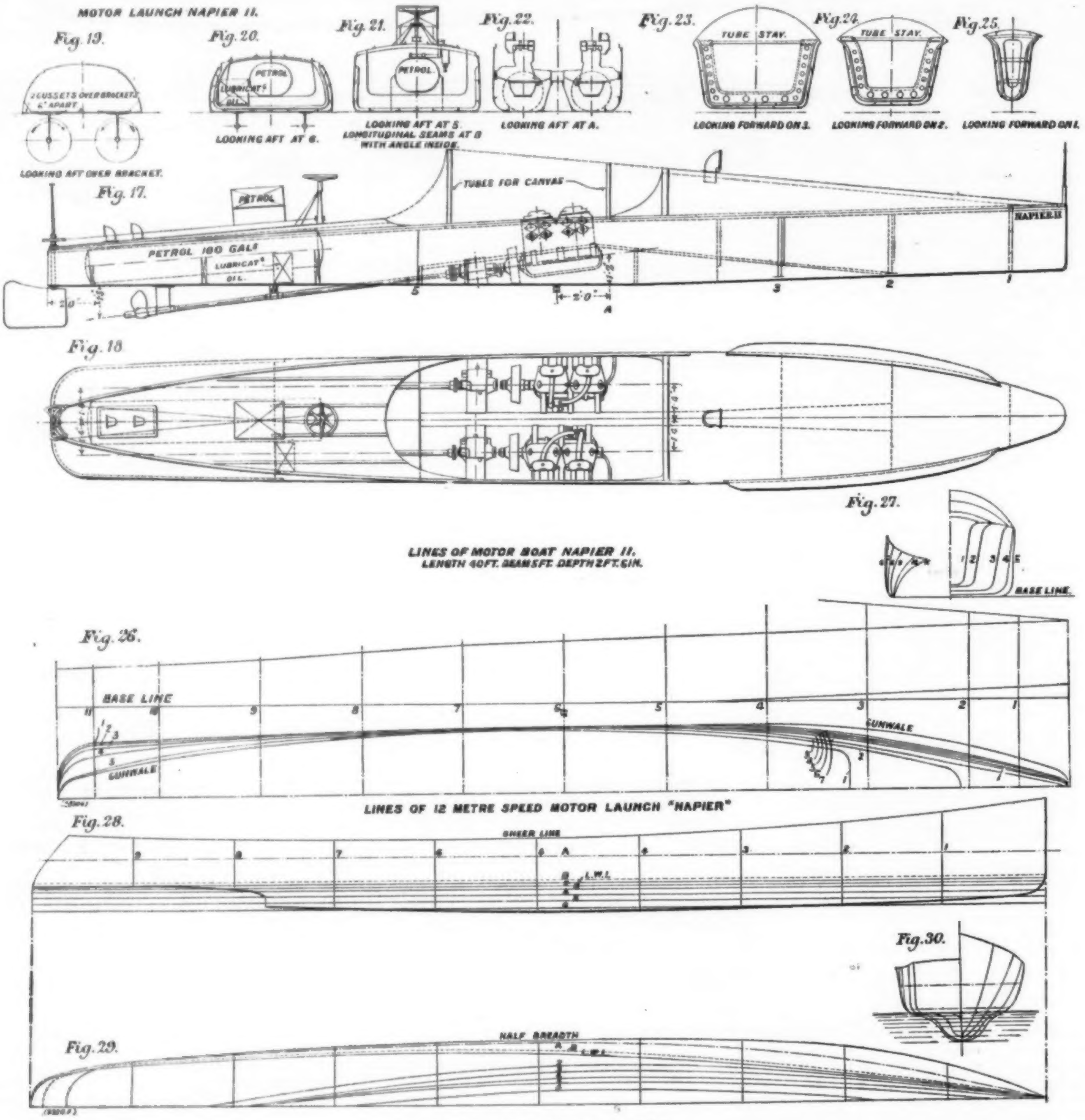
METHODS OF CONSTRUCTION AND MATERIALS USED.

Some of the earlier motor-boats, including "Napier I." and "Napier II.," were built of steel, but it has been found that steel is an unsuitable material for light high-powered boats under 50 feet in length. The chief disadvantages are, first, the difficulty of obtaining a fair surface, which is of great importance in this type of boat, and, secondly, the difficulty of making satisfactory joints in the thin material which has to be employed. Considerations of weight and expense tend also largely in favor of wood in the construction of such boats. The weight of hull of "Napier II." was 1.47 tons for 140 horse-power, but a similar hull of a suitable wood construction need not have weighed more than 10 hundredweight complete. For such light boats wood has many advantages over steel for resisting local stresses, and is also on a level with steel for relieving structural stresses. The systems of wood construction commonly adopted are: (1) Ordinary carvel planking with cut or bent timbers. (2) Double skin, without timbers for small boats, and with timbers for larger boats, or for higher powers. (3) Treble skin, with or without timbers. The first method (planks and timbers) is safe to employ where weights need not be greatly cut down, and it is also the cheapest. The second system (double skin) is that most commonly employed for high-powered boats, and gives satisfactory results in every way. For light, fast launches up to 25 feet in length timbers need not be used, and in boats of greater length, or with higher powers, bent timbering may be introduced with advantage. The construction plan of "C. G. V.," a racing launch of 130 horse-power, shows an example of this method of building, the details being:

Length over all	11.99 meters (39 ft. 4 in.)
Breadth, extreme, over planking	5 ft.
Depth amidships to coaming	3 ft. 6 in.
Draft amidships	8 in.
Draft, extreme, at propeller	2 ft. 3 in.
Displacement, total	1.7 tons.
Weight of hull department complete	750 lb.
Weight of machinery department complete; tank full	2,700 lb.
Load at designed water line	350 lb.

The sheer draft and outline construction plans of this boat are appended (Figs. 12 to 15). The lantern-slide (not reproduced) shows another example of the double-skin system of construction showing a 40-foot boat designed for use as a light river launch. The third system (treble skin) is more expensive, without corresponding advantages. Other systems have been introduced, including the "ribband-carvel" system, consisting generally of a light single carvel skin with very light timbers, and having the edges fastened by means of edge strips inside, scored over the timbers. This system gives a somewhat lighter hull than No. 2, but is much more expensive, and necessitates highly-skilled workmanship. Saunders's sewn system is also largely adopted for speed launches; by this method two, three, four, and occasionally five skins of very light veneer are sewn together with copper wire, producing a form of skin which is exceedingly strong, and which may also be built to forms which are almost impossible by any other system, each skin being laid on separately, and the whole afterward sewn together.

It will be noticed that in most of the high-powered launches the requisite longitudinal strength is chiefly obtained by extending the solid wood girders carrying the machinery over a great part, or the whole, of the length of the boat. An extension of this idea has been recently devised, according to which the skin or shell of the vessel is not required to contribute di-



HIGH-SPEED MOTOR BOATS.

rectly to the structural strength, the engine girders being constructed to form, in conjunction with one or more other members and suitable transverse framing, a complete framework in themselves. The lantern slide (not reproduced) shows a rough example of this construction, showing a combination of the engine girders with a light upper member, producing a complete framework capable of resisting all the ordinary structural stresses, to which is attached a skin of any suitable material, which need not be stronger than required to withstand local stresses due to waves, etc. It is obvious that this method lends itself to many adaptations for larger type of light high-speed vessels, as the upper members of the complete girder may be placed in any desired position, so as not to interfere with the internal arrangement of the vessel.

MODERN DEVELOPMENTS.

Although not strictly within the scope of this paper, three more designs may be mentioned (though not illustrated in the paper) as illustrating the recent trend of motor-boat design, and as showing that the internal-combustion motor is now far beyond its experimental stages. The "Ruinie" represents an ordinary sailing yacht fitted with a motor of about 15 brake horse-power, driving her at a speed of about 7 knots, and occupying so little space as not to interfere in any degree with the accommodation of such a yacht, the total weight of the engine installation, including propeller and all gear, and tank with 15 gallons of fuel, being 0.7 ton. The second design shows a larger yacht, of 32 tons Thames measurement, in which the sail-power is auxiliary to the motor-power, although the latter occupies a very small part of the vessel's capacity. It will be noticed that the accommodation is almost equal in extent to that of a sailing yacht of the same length. The third design is that of a boat for commercial purposes, designed to carry fifty passengers for short day trips. In this case the weight of machinery required to drive the boat at a speed of 8½ knots loaded is only 9.3 per cent of the total displacement, the particulars being:

	Tons.
Weight of hull department complete.....	2.85
Load with 2 feet 4 inches freeboard.....	2.64
Weight of machinery department complete with 20 gallons of petrol........	.56
Total displacement	6.05

MEASUREMENT OF RESISTANCE.

THE simplest method of measuring resistance is that known as the substitution method in which the un-

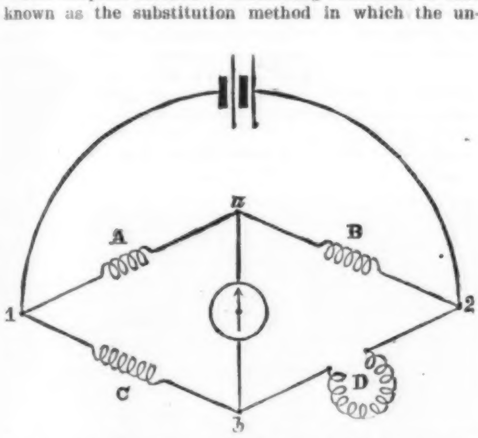


FIG. 1.—DIAGRAM OF WHEATSTONE'S BRIDGE.

known resistance and a galvanometer are placed in the circuit of the battery. The deflection of the galvanometer needle is noted. A variable known resistance is then substituted for the unknown resistance, and adjusted until the deflection is the same as in the first case. The variable known resistance will then equal the unknown resistance. If the current is so great as to cause a deflection of the needle much exceeding 45 deg., it should be reduced either by removing some of the battery or by the introduction of extra resistance into the circuit. The same conditions must obtain throughout the measurement.

The Wheatstone bridge presents the best known method of quickly and accurately measuring resistances. Any galvanometer may be used in connection with the bridge, the Deprez-D'Arsonval galvanometer being the best for most purposes. The bridge method was originally devised by Mr. Christie. The late Sir Charles Wheatstone's name is attached to the invention, in consequence of his having brought it before the public. The principle of this apparatus is illustrated in Fig. 1. A current, in passing from 1 to 2, divides, a part passing over 1, *a*, 2, another part passing over 1, *b*, 2. For every point in 1, *a*, 2 there is a point in 1, *b*, 2 having the same potential. If these two points of equal potential be joined by a conductor, no current will pass through the conductor. In the diagram the points of equal potential are marked *a*, *b*, and they are connected by a conductor in which is inserted a galvanometer.

A, *B*, and *C* are known resistances, and *D* is the unknown resistance. When $A : B :: C : D$, the galvanometer needle will stand at 0. The resistance, *C*, is variable, so that when the unknown resistance, *D*, is inserted, the resistance, *A*, is adjusted until the needle falls back to 0.

The commercial form of Wheatstone's bridge is represented in Fig. 2.

In this instrument a number of coils are suspended from the vulcanite cover of the box and connected with brass blocks attached to the cover in the manner shown in Fig. 3, which represents a part of the resistance box.

The terminals of the coils are connected with adjacent blocks, so that a current entering at *A* will pass from the first block down through the first coil, thence to the second block. In the present case the second and third blocks are connected electrically by a plug inserted between them, so that the second coil is cut out, the current taking the path of least resistance. The current can pass from the third to the fourth blocks only by going through the third coil, and to pass from the fourth block to the fifth, the current must pass through the fourth coil. Whenever a plug is inserted it cuts out the coil connected with the

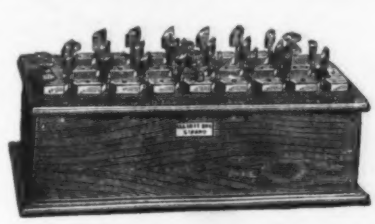


FIG. 2.—BRIDGE RESISTANCE BOX.

blocks between which the plug is placed, and when a plug is removed, the coil at that point is thrown into the circuit. The coils of the resistance box are wound double, so that the current passes into the coil in one direction and out of it in the opposite direction, thus perfectly neutralizing any magnetic effects.

Fig. 4 represents the top of the bridge resistance box, and the circuits diagrammatically. The three branches, including the known resistance of the bridge, are contained in the resistance box. In this diagram the connections of the battery and galvanometer, as shown in Fig. 1, are transposed for the sake of convenience in calculation, but the results are the same. The resistances, *A B*, of Fig. 1 are each replaced here by three coils of 10, 100, and 1,000 ohms. These are called the proportional coils. The rest of the resistance box constitutes the adjustable resistance; and *x*, connected at *D* and *C*, is the unknown resistance.

The galvanometer is connected at *D B*, and the battery at *A C*. The value of the unknown resistance, *x*, is determined by simple proportion:

$$x : R :: s : S.$$

As shown in Fig. 4, the variable resistance $R = 2{,}163$ ohms, $s = 10$ ohms, and $S = 1{,}000$ ohms, therefore $x = 21.63$ ohms.

The value of the proportional coils may be expressed as follows:

$$\frac{10}{1000} = \frac{1}{100}$$

$$\left.\begin{array}{c}\frac{10}{100}\\[4pt] \frac{100}{1000}\end{array}\right\} = \frac{1}{10} \qquad \begin{array}{c}\text{Also}\\ \frac{1010}{100}\end{array}$$

$$\left.\begin{array}{c}\frac{10}{10}\\[4pt] \frac{100}{100}\\[4pt] \frac{1000}{1000}\end{array}\right\} = 1 \qquad \begin{array}{c}\frac{1100}{10}\\[8pt] \frac{10}{1100}\end{array}$$

$$\left.\begin{array}{c}\frac{100}{10}\\[4pt] \frac{1000}{100}\end{array}\right\} = 10 \qquad \frac{100}{1010}$$

$$\frac{1000}{10} = 100$$

The arrangement of the proportional coils may be 1,000 : 1,000 for large resistances, and 10 : 10 for small resistances. In using the Wheatstone bridge in testing cables or in measuring the resistance of an electromagnet or a coil, to avoid delay caused by the deflection of the needle before the current becomes steady,

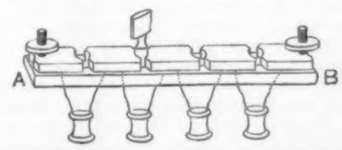


FIG. 3.—RESISTANCE BOX CONNECTIONS.

it is best to send a current through the four arms of the bridge (*s*, *S*, *R*, *x*) before it is allowed to pass through the galvanometer. This is accomplished by means of the bridge key, shown in Fig. 5, together with its connections.

This is in reality nothing more than a double key arranged to control the two parts of the circuit independently, the upper key being arranged so that after it is closed it may be still further depressed to close the lower one, the two keys being separated by an insulating button.

The binding posts, *a b*, of the upper key are inserted in the wire which includes the battery, while the binding posts, *c d*, of the lower key are inserted in the conductor including the galvanometer. When this key is depressed, it first sends the current through the arms of the bridge, and then allows it to pass through the galvanometer.

CONTEMPORARY ELECTRICAL SCIENCE.*

GRAVITATIONAL ENERGY.—The radiation resulting from the acceleration of electrons implies a degradation of energy, and V. Crémieu puts the question as to whether a corresponding degradation of energy can be

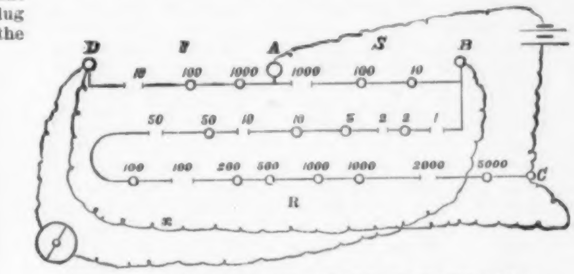


FIG. 4.—DIAGRAM OF BRIDGE CONNECTION.

traced in connection with the generation or destruction of gravitational energy. If it cannot, then gravitational energy is the only form of entirely reversible energy hitherto known. He has endeavored to approach this question experimentally along several different lines of investigation. One of them consists in determining the gravitational constant in liquids, where it should be the same as in air in accordance with hitherto accepted opinions. He succeeded in determining the constant in water under favorable conditions, but could not obtain any decided indication of an effect of the medium. He also endeavored to detect some effect of the abrupt acceleration by free fall of the attracting body, arguing that by Lenz's law the energy liberated would produce a motion in the attracted object tending to oppose the relative motion. He looked for an impulse of the attracted object in the direction of the fall, but failed to find it. In another experiment he formed in a bath of olive

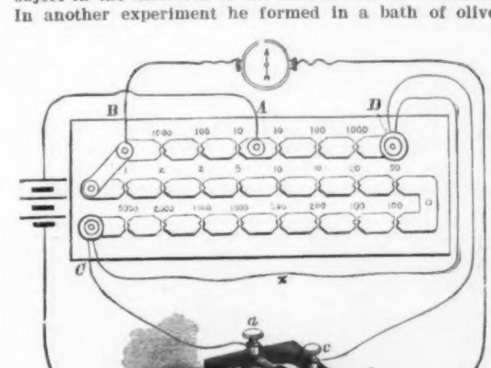


FIG. 5.—BRIDGE KEY AND CONNECTIONS.

oil several drops of a mixture of alcohol and water of the same specific gravity as the oil, and found that they were apparently attracted toward each other, although neither capillarity nor ordinary gravitational attraction could be alleged as the cause of the attraction.—V. Crémieu, Journal de Physique, January, 1906.

SPARKING THROUGH CONDENSED GASES.—C. and H. Guye have examined the dielectric strength of gases compressed in a Cailletet tube under pressures up to 80 atmospheres. They find that up to about 10 atmospheres the spark potential increases linearly with the pressure. At higher pressures than that the spark potential increases more slowly than the pressure. The potential and pressure curves take the form of a parabola. Nitrogen shows a peculiarity in the shape of a maximum which coincides with the maximum compressibility and the minimum *pv* of the gas. In air, the results also show a slight elevation of the curve near the highest pressure used. But no such behavior was found in either hydrogen or oxygen, no doubt owing to the fact that the minimum *pv* is beyond the range of pressures used. The authors also made a few experiments on carbonic acid near its critical point, and found indications of a diminution of the spark potential as the critical point was approached; but the partial decomposition of the gas produced by the spark makes the interpretation of the results somewhat uncertain. The values of the potentials recorded for CO_2 range from 10 to 60 electrostatic units at 18 deg., and from 10 to 54 units at 33 deg., the distance being 0.2 millimeter. The authors also tried the effect of X-rays and of radium rays, but could not detect any perceptible difference produced by them.—C. and H. Guye, Physikalische Zeitschrift, January 15, 1906.

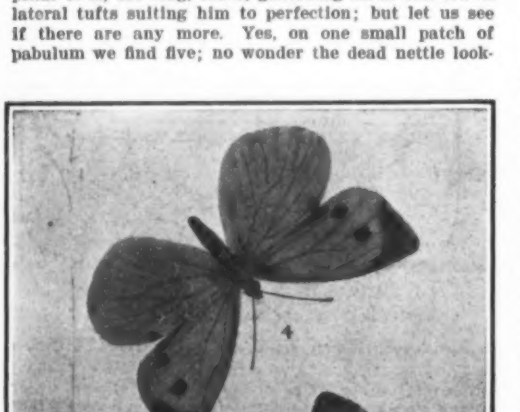
* Compiled by E. E. Fournier d'Albe in the Electrician.

SUMMER LEPIDOPTERA.

By H. DOLLMAN.

'TIS summer again. From yonder copse the cuckoo greets its mate, immediately without the window sits a song-thrush giving forth its clear and liquid note, as if for pure joy that spring has come. All Nature seems to bid us come to greet her, so for the time let us be her guest, and study her in one of the most beautiful of her phases. As we stroll gently down the winding lane toward the copse, the copse from which we heard the cuckoo call, a white butterfly breaks suddenly from a patch of dead nettle, and then, seeming to understand that we intend no harm, settles again. Let us approach gently, and the timorous creature may allow us to observe it for awhile. But where has it gone? We saw where the butterfly settled, and yet it has now disappeared, although we are sure it has not flown away. Suddenly the sun shines forth again, and behold! our white butterfly gently flits from the very spot we have but lately searched in vain. Now for what have we been looking? Probably for a pure white butterfly with all four wings fully expanded, as we are accustomed to see in the cabinets of entomological friends. But when "the white" settled on the grass it folded its wings one against the other above the body, and thus, if looked at from immediately in front, shows but as the thickness of a narrow blade of grass. Neither is it the snow-white color we expected, for the under-side of its wings is of a yellowish white color, tinged with pale green, somewhat the color of young grass blades with a high light upon them. Thus has Nature already instructed us in one of the many methods she has for protecting her progeny. The white butterfly may have been one of two species, either the common white (Pieris rapæ; No. 1 in the first picture), or the green-veined white (Pieris napi). The latter differs from the former principally in having the veins of the wings more strongly indicated by gray-green scales, hence its popular name of green-veined white. The females of both Pieris rapæ and P. napi differ from the males in having an additional black spot on each anterior wing, and in having also many more dark-colored scales on both anterior and posterior wings in the region of the thorax. The interior wing on its posterior border has also a dark club-shaped mark in the female not exhibited in the male.

While we searched among the dead nettle for our white butterfly, we could not help noticing how its leaves had been devoured by some rapacious creature. Let us see if we cannot run this devastator to earth. No, he does not seem to be here. Let us look at that other patch of dead nettle yonder; perhaps that may harbor him. There he is, that large, black woolly-bear, sunning himself so luxuriously, evidently resting after his late display of voracity. What a fine big caterpillar it is, the long, black, glistening hairs and brown lateral tufts suiting him to perfection; but let us see if there are any more. Yes, on one small patch of pabulum we find five; no wonder the dead nettle look-



WHITES AND ORANGE-TIPS.

ed rather *passé*. They are the caterpillars of the garden tiger moth (Arctia caia; No. 2 in the second illustration), and will soon be turning to pupæ, from which will emerge those noble great moths, whose brilliant under wings make them, once seen, long remembered. It feeds on many plants besides the dead nettle (Lamium alba), the stinging nettle (Urtica dioica) being its principal food, and others such as the various species of dock (Rumex), elm (Ulmus campestris), etc., being sometimes patronized.

There is another tiger moth caterpiller to be found in the springtime, though it is a little late for it now. It is the cream-spot tiger moth (Arctia villica; No. 1 in the second picture), and well worth our searching for, as perchance we may come across a late example. The caterpillar is found on grassy hedgerows similar to that from which we have just taken the common

TIGER MOTH CATERPILLARS.

woolly-bear; it likes to sun itself in little depressions among the soft grass where the sun is hottest. It is too late for it, I fear; we—— Wait! Who is this crawling on the road? Surely it is a cream-spot! We are fortunate indeed; it is it, beyond all doubt. The clear, dark red legs and head are most distinctive, and the color of its hairs is not to be mistaken. It feeds on many low plants, such as groundsel (Senecio jacobæa), dandelion (Taraxacum densleonis), etc., and is far from a rare species, though not nearly as common as the garden tiger. We walk on through the narrow lane, discussing the various species of tiger moths, and ever and anon glancing at the hedge-bank to see if we can detect further spoils, when suddenly a rapidly-moving spot of sulphur yellow attracts our attention. It is a male brimstone butterfly (Gonopteryx rhamni) flying in the sunshine. The brimstone hibernates in the butterfly state, and is occasionally lured out even in the month of January by an especially propitious day, and seems very out of place among leafless trees and flowerless hedgerows. The female is considerably lighter than the male, being of a pale greenish white color instead of the characteristic brimstone yellow of the male. These hibernated specimens will soon have perished, when the females have finished depositing their isolated eggs upon the leaves or shoots of the buckthorn (Rhamnus). From these eggs our summer brood is produced, they in turn hibernating until the next spring. Other butterflies which hibernate in the butterfly state are to be found among the angle-wings (Vanessa), one of which, the small tortoiseshell (Vanessa urticæ), we are almost certain to see flying over the nettles by the old barn at this corner. Let us go quietly. Yes! Do you see him?—settled upon that dandelion flower, a red and black fellow most easily perceived on the left in the fifth photograph. Its caterpillar feeds upon the stinging nettle (Urtica dioica), and, therefore, the hibernated examples are generally to be found flying around nettle beds in springtime, prior to oviposition. The nearest ally to the small tortoiseshell is the large tortoiseshell (Vanessa polychloros), a somewhat similar butterfly, but larger and more somber in color. It is generally found after hibernation flying round elms, the most usual food-plant of its caterpillar. It also feeds on sallow (Salix). We may see other species of Vanessa before we end our walk, but let us look at this thick whitethorn hedge for a few minutes; there are two large caterpillars that we might find on it, those of the oak-eggar moth (Bombyx puercus; on the left) and the lappet moth (Lasiocampa quercifolia; on the right of the fourth illustration). The oak-eggar is soon found, and a pretty caterpillar it is, the velvety black of the segmental divisions contrasting well with the ochraceous brown of the segments. But beware of those innocent-looking hairs; they can produce a most disagreeable irritation of one's skin, somewhat akin to that of nettle stings, only far more durable, and for them "dock" is no antidote. This irritating property, also met with in other hairy caterpillars, is, no doubt, of a strong protective value, serving a similar purpose as a nauseous taste. It is seen very well developed in the caterpillars of the gold-tail moth (Porthesia similis), another whitethorn feeder. It is necessary to search very carefully for the caterpillar of the other whitethorn-feeding species I mentioned (the lappet moth), inasmuch as it has a strong protective resemblance to the stems of the plant. It is a dorsi-ventrally depressed caterpillar, and lies quite flat along the branches, thus appearing as nothing more than an excrescence on the branch. Its color is also protective, being dark gray-brown with a few flecks of white about it, very similar in general effect to the color of a normally-colored branch. If the stems of the food are lichen-covered, there is a strong tendency toward a mottled yellowish green appearance, intermingled with the normal dark gray, thus closely assimilating with the lichen-covered bark. Similarly, if the branches of the pabulum are of a dark reddish brown hue, the caterpillar assumes a similar system of coloration. Besides the common whitethorn (Cratægus oxyacantha), it feeds on blackthorn (Prunus spinosa), buckthorn (Rhamnus), various species of salix, etc., and generally feeds at night-time, when it may be captured by searching the above-mentioned bushes with the aid of a lantern. Here we are at the copse at last. Let us take this broad ride leading through to the Wick farm road; it is gayly bedecked with cuckoo-flower, and we may therefore chance on an early orange-tip butterfly (Euchloe cardamines). For a moment we stop to watch a humble-bee fly as it poises itself in the air, quite motionless, then darts like an arrow toward some nectar-giving cup. A humble-bee fly—to me it is the emblem of spring! As we turn from watching it we see a male orange-tip butterfly gently flying past. He is marked No. 2 in the first photograph, and the female No. 3. She has not got those gay orange tips to her wings, but is far plainer, being not unlike a white butterfly, and apparently is much more rarely seen than her mate; this may, however, be largely due to the fact that she is so much less conspicuous. When her brief span of life is drawing to a close, she will deposit her eggs on the cuckoo-flower (Cardamine pratensis), from which eggs will emerge the small yellowish green caterpillars, that will rapidly mature, and hibernate as pupæ. When full fed, the caterpillar is green, and lies along the narrow seed-pod of its food, with which it assimilates extremely well, and to judge by the profusion of the butterfly, very efficaciously.

You saw that big butterfly that just passed us with the swiftness almost of a hawk; that was a red admiral—the soaring flight is very characteristic of a Vanessa. The red admiral (Vanessa atalanta), like the other Vanessa I previously mentioned, has passed the dreary months of winter in passive hibernation. Its caterpillar feeds on stinging nettle, and is to be found principally on nettle-beds by farm-buildings, etc.; he spins a leaf or leaves together, forming a small covered-in domicile, within which he lives, one would think fairly safe from his enemies. But, alas for him!

DRINKER AND ANGLE-SHADES.

a small ichneumon fly has learned to recognize his abode, and a very large percentage of the admiral caterpillars fall a prey to this noxious little parasite. We have now come out into the road again, and on a small piece of waste land just outside the copse three orange-tip butterflies sport themselves in the morning sunshine; in a few days' time the lanes will be alive with them, bright spots of moving orange everywhere. A

patch of dock arrests our attention; we stop in hopes of taking some more of the common woolly-bear caterpillars, this being quite as general a food-plant for the garden tiger moth as dead nettle. We look in vain, however; this is evidently not a favored spot for "tigers," yet the dock is eaten by some creature. On more careful search we find the cause of the damage; he is a smooth, velvety, green caterpillar, of the angle-shades moth by name.

The angle-shades caterpillar (Phlogophora meticulosa; marked No. 3 in the third picture) has two forms—one the green, which we have just found, the other a brown-colored one (marked 2). The brown form feeds at night, sheltering at the roots of grass, etc., by day. The reason of this is, of course, that the brown caterpillar would be so obvious on its green food-plant by day that it would immediately fall a prey to any passing bird; the green form harmonizing with the green leaves permits the former to feed by day in comparative safety. There goes a butterfly we all know—the peacock, and a fine example, too. Notice when he flaps his wings their under side is of a dark black-brown color. This is because he has to hibernate in old barns, hollow trees, etc., where if he had gaudily-colored under-wings he would soon be betrayed. The peacock (Vanessa io) is a most distinct butterfly, and is perhaps one of the most generally known of any, a fact probably accounted for by the prominent eye-like spots on the wings (hence its name peacock) and the general richness of its coloration. There is another very well-known butterfly that with great good fortune we might come across to-day—the clouded sulphur (Colias edusa) is the one I mean. It seems very doubtful, however, as to how many of those examples seen in England in the spring have hibernated in this country. Probably by far the greater number of them are fresh immigrants from the Continent. After a very large influx during the previous year it is possible, however, that a few may manage to find a very sheltered spot, and thus survive the ordeal of our wet winter. That white butterfly over there looks considerably larger than any others we have seen. Surely it is something fresh! Yes, that is the large white (Pieris brassicæ; No. 4 in the first illustration), and, by the black spots on the fore wings, it is a female. See! she has settled, and you can see her well. The male has only a black tip to the anterior wings, those black spots not being represented. It is sometimes very common, is this white, the caterpillars doing an immense amount of damage to cabbages (their favorite food-plant); hence it is often called the cabbage white. The caterpillar has a similar kind of enemy as the red admiral has, however, and a large percentage of them are always killed by ichneumon flies. By the irony of fate they are not thus exterminated until they are practically full fed, or even until they are pupæ, thus being allowed to complete their devastation on the cabbages before their death. It also feeds on nasturtium, rape, and on a few other low-growing plants.

There is a white I have never taken, known as the Bath white. It is not really an indigenous species,

OAK-EGGAR AND LAPPET CATERPILLARS.

but a friend of—— Look! a painted lady! You see it? There, by that humble-bee. Ah! it is off, alarmed, I fear, by my voice; but even a fleeting glance at such an old friend is delightful. It is the Vanessa cardui of the lepidopterist, and in certain years is by no means rare—in fact, sometimes prolific. What is this? Some large caterpillar at rest upon a tall grass blade, and not unlike an oak-eggar in general shape? That is the caterpillar of the drinker moth (Odonestis potatoria; No. 1 in the third picture), and is to be generally found sitting on grass stems in that manner in late spring; it is a very generally distributed species. But what is the time, I wonder? It is 1.30; so, if our hostess, with whom we have been so well entertained, will excuse us, we will return.—Country Life (London).

[Concluded from SUPPLEMENT No. 1594, page 25543.]

INSECTICIDES: THEIR PREPARATION AND USE.*

6. Arseniate of Lime.

WHITE arsenic and lime may be made to combine, forming an arsenite of lime that is practically insolu-

TORTOISESHELL AND RED ADMIRAL.

ble in water. The poison may be prepared in either of two ways. What is known as the Kedzie formula is as follows:

"Boil two pounds of white arsenic and eight pounds of salsoda for fifteen minutes in two gallons of water. Put into a jug and label 'poison' and lock it up. When ready to spray, slake two pounds of lime and stir it in forty gallons of water, adding a pint of the mixture from the jug."

The other method is to boil together arsenic, lime, and water for a full half hour in the following proportions:

White arsenic	1 pound
Lump lime	4 pounds
Water	4 gallons

Then dilute to 200 gallons of water before applying to foliage.

These preparations have become very popular in the past few years, and deservedly so. White arsenic is cheap and consequently is in very little danger of adulteration, so that one is almost certain of the strength of his mixture when using this poison. Care must be taken, however, to *use fresh slaked lime of good quality.*

Before being diluted for use, the mixture should be passed through a coarse cloth or sieve, to take out the lumps that would otherwise clog the spraying nozzle.

7. London Purple.

London purple is a by-product in the manufacture of aniline dyes and has for its active principle arsenite of lime. It also contains some free arsenic, lime, coloring matter, and other impurities. The amount of arsenic present is subject to considerable variation, but will usually range between 40 and 55 per cent. As there is often considerable soluble arsenic present, it is always best to use a pound or two of freshly slaked lime with every pound of the poison if used in water.

This poison is finely divided and remains in suspension in water much longer than Paris green does and it usually sells at about two-thirds the price of that poison. It seems to be going into disfavor because of its variable composition and the danger of its burning foliage. It is also considered somewhat less effectual in killing insects than is Paris green or Scheele's green. It should compare favorably, however, with the prepared arsenite of lime in its power to kill insects, and there is little danger that it will be adulterated, as it is a waste product.

Apply either wet or dry in the manner and in the same proportions as are previously recommended for Paris green, being sure to add a pound or two of freshly-slaked lime for each pound of poison if used as a spray.

8. Bordeaux Mixture and the Arsenites.

Bordeaux mixture is a fungicide and is the substance most often used for the destruction of fungous diseases that attack the surface of the plants. It has been found to be of value for use against flea-beetles, and the writer also demonstrated its value a number of years ago as a medium in which to spray Paris green or London purple. These poisons can be used very strong in this mixture without injury to foliage and they do not in the least lessen its effect as a fungicide. Such a mixture will destroy both insects and fungi with one application.

Bordeaux mixture may be prepared as follows: Take of:

Copper sulphate	4 pounds
Quicklime	4 pounds
Water	45 gallons

Dissolve the copper sulphate in a gallon of hot water, slake the lime in another gallon of water, and then add the milk of lime slowly to the copper sulphate solution while the latter is being constantly stirred. Then add 43 gallons of water.

If insects are to be killed at the same time, add to the above quantity of Bordeaux mixture one-third pound of London purple, Paris green, or Scheele's green, or two pounds of arsenate of lead.

9. White Hellebore.

Hellebore, as obtained from drug stores, is a light, yellowish-brown powder. It is a vegetable poison and is obtained by pulverizing the roots of a European plant *Veratrum album.* It is not as poisonous as the arsenites and consequently it is not as effective in the destruction of most insects, but it has its special uses. Slugs, which are the young of saw-flies, are particularly susceptible to its effects. The poisonous property is an alkaloid and it loses its virtue after being exposed to the air for a few days. For this reason it cannot be used where it is likely to remain long before being eaten, and it must be kept in tight receptacles and must not be kept too long before using. It is often useful for the destruction of insects upon plants containing fruit that will soon be used for food.

Dry applications are easily made upon low plants by making a small cheesecloth sack, through which the dust may be sifted lightly over the foliage. The best time to apply is in the evening.

In the wet way use:

White hellebore	1 ounce
Water	3 gallons

Apply as a spray in the evening.

10. Borax.

Used chiefly for the destruction of cockroaches. Spread the powdered borax upon bread, sweet potato, or banana peelings, or mix with sweetened chocolate, and place the bait where the cockroaches can get at it.

SUBSTANCES THAT KILL BY EXTERNAL CONTACT.

Substances in this group are chiefly used against insects that take liquid food from beneath the surface of the plant by means of a tubular rostrum or beak, but they may be used against many other soft-bodied insects with success. Insects having a hard outer crust to their bodies resist these substances and are not easily killed by them. If insects are covered with a powdery or cottony material, the insecticide will have to be applied with considerable force to cause it

1. CLOUDED SULPHUR. 5. LARGE TORTOISESHELL.

3. MALE BRIMSTONE. 4. VANESSA CARDUI.

to penetrate to the body. Applications must always be thorough, because only those insects will be killed that have the substances thrown upon them.

11. Soap.

The ordinary soft soaps and laundry soaps have long been used for the purpose of killing vermin on plants and animals, and they have considerable insecticidal value, particularly for the destruction of very

* Abstract of a monograph by C. P. Gillette, published by the Agricultural Experiment Station of Colorado Agricultural College.

tender insects, like plant lice. The soaps that are specially useful for the destruction of insects are sold as whale-oil soap, fish-oil soap, or tree soaps. Whatever the name, the oil is usually fish oil.

12. Whale-Oil or Tree Soap.

For ordinary plant lice one pound of the soap to eight or ten gallons of water is sufficient if the application is thorough. Double this strength will not injure most plants and is often required to destroy more resistent insects. For scale lice, like the San José scale, for example, it is used as strong as a pound, or even two pounds, to a gallon of water. These strongest applications can only be used in the winter or early spring when the trees are dormant. The soap is more effectual if applied when quite hot.

13. Fish-Oil Soap (Home-Made).

Lodeman, in his "Spraying of Plants," gives the following formula for the preparation of fish-oil soap:

Potash lye	1 pound
Fish oil	3 pints
Soft water	3 gallons

Dissolve the lye in boiling water and then add the oil and boil for two hours longer. When using, dissolve a pound of this soap in from six to ten gallons of water. Use for the same purposes as whale-oil soap, and in the same strengths.

14. Kerosene Emulsion.

This preparation is probably the best general-purpose insecticide for the destruction of insects by external contact. The materials composing it are always at hand and it is not difficult to prepare after one has had a little experience. Soft water should be used, if possible. If hard water is used it may be necessary to "break" it first by adding washing soda or potash lye.

To make the emulsion use the ingredients in the following proportions:

Soap	1 pound
Kerosene	2 gallons
Water	27 gallons

Prepare by dissolving the soap in a gallon of water; then, while the soapy water is boiling hot, remove from the fire and immediately add two gallons of kerosene and agitate briskly for a few minutes. If a large amount is being made, use a force pump and forcibly pump the mixture back into the receptacle that contains it until all is a frothy, creamy mass. If such a mixture is not obtained in a very few minutes, put the whole over the fire again until it boils, and then repeat the pumping, and the emulsion will almost surely form. When put back for reheating, *watch every moment to see that it does not boil over and take fire.* This work should be done out of doors. After the emulsion is made, add the remaining 27 gallons of water and all is ready for use.

Small quantities may be emulsified with a rotary egg-beater.

Whale-oil soap, or any cheap soap, may be used.

Clean dishes and clean water should be used. Every particle of dirt in the emulsion serves as a center of attraction about which the oil droplets will collect and then rise to the top to form a film of oil on the surface.

The strength above given is suitable for most insects. Most plant lice may be killed with an emulsion of half the above strength.

15. Kerosene-Milk Emulsion.

Kerosene will emulsify with milk, also, and when small quantities are wanted it is often less trouble to use the milk than to prepare the soapy water. These proportions are:

Milk (sour)	1 gallon
Kerosene	2 gallons

Dilute with water as in the preceding formula. If sweet milk is used, add a little vinegar. Otherwise it may be impossible to form a stable emulsion.

16. Kerosene and Crude Petroleum.

These oils are used pure, and also diluted with water, for the destruction of scale and other insects. Experiments in the Eastern States seem to indicate that the safest time to apply is early in the spring, just before the buds swell, and on a bright, windy day when the oil will evaporate rapidly. It seems that when applied in moderation, in the proportion of 40 parts of the oil to 60 of water, these substances will seldom injure apple, cherry, or pear trees, but can hardly be applied to tenderer trees, such as peach and plum, without further dilution.

When diluted with water in the form of a spray they may be used upon foliage of most plants, without injury, in the proportion of one of the oil to five or six of water. Most plant lice are killed in mixtures as weak as one of oil to fifteen or twenty of water.

Pumps are now made for the purpose of mixing the oil and water in the form of a spray, and so do away with the need of preparing an emulsion. The one who has the insecticides to apply must decide whether or not he will go to the extra trouble of making the emulsion or whether he will go to the extra expense of purchasing a special and somewhat more costly pump that may not work very satisfactorily at all times.

17. Gasoline.

This oil is also destructive to insect life. Its chief use is for the destruction of bed-bugs. It is applied pure by means of an oil-can or hand atomizer. To be effectual the bugs must be thoroughly treated with it. As it is inflammable, care must be taken not to bring fire near until the apartments where it is used are well aired.

18. Turpentine.

Turpentine is used for the same purposes as gasoline and the same precaution applies.

19. Lye and Washing Soda.

These substances are in considerable popular favor for the destruction of insects, but the writer's experience with them has not been encouraging. In the proportion of a pound to three gallons of water they may be used upon the trunks of trees and will kill soft-bodied insects that might be wet by them. To be used upon foliage they should be diluted to a pound to forty gallons of water, and in this strength they will hardly destroy the tenderest of insects. Kerosene emulsion and whale-oil soap are much more effectual insecticides.

20. Lime.

Lime, either wet or dry, may be used freely upon foliage without fear of injury. It is of very little value as an insecticide. When freshly slaked and freely dusted upon the slugs that infest pear, cherry, and plum trees, it causes them to drop off and most of these perish. Experiments at this station have not been wholly successful in killing slugs in this way. As a coating upon the bodies of fruit trees it undoubtedly does much to prevent sun-scald late in winter and early in spring. The addition of a liberal amount of skim milk or salt, or both, to the preparation will greatly increase its adhesive qualities. The following formula is printed in the 1899 report of the Canada Experimental Farm:

Skim milk	6 gallons
Water	30 gallons
Lime	60 pounds
Salt	10 pounds

21. Lime, Salt, and Sulphur Wash.

This wash, when properly made, is one of the most effectual applications for the destruction of scale insects and eggs of the brown mite, particularly in dry climates, like that of Colorado. It should be used only in the winter or spring, while the trees are dormant. The ingredients may be in the following proportions:

Lump lime (good)	20 pounds
Sulphur	15 pounds
Salt	10 pounds
Water	50 gallons

Slake the lime, preferably with hot water, in an iron kettle or a barrel, and while slaking, slowly add the sulphur and stir it in. Then boil over a good fire or by means of a jet of steam in about one-half the required amount of water (25 gallons) for an hour or two, or until a dark red color is obtained. Then add the salt and boil for 15 minutes longer, strain, dilute to 50 gallons, and apply while hot. Many are leaving out the salt and they seem to have just as good results.

22. Pyrethrum, Buhach, or Persian Insect Powder.

This substance is a vegetable powder and is obtained by pulverizing the dried blossoms of plants of the genus Pyrethrum. It may be obtained at almost any drug store, and is peculiar in its power to kill insects while it is not poisonous to the higher animals. It may be used either wet or dry. If applied in water, use in the proportion of:

Pyrethrum	1 ounce
Water	3 gallons

If applied dry, use pure and make a very light application, or dilute with flour and apply more freely.

If thoroughly disseminated in the air of a room it will soon bring to the floor all the flies and mosquitoes therein. A good way to rid a room of flies is to make a thorough dusting of the powder through the room and then close the room tightly for the night. Then in the morning sweep up the flies and burn them. If they are not destroyed in this way after being stupefied, many will finally overcome the action of the powder and live.

23. Tobacco.

Tobacco has long been used in one way or another for the destruction of insects. Its chief use seems to be for the destruction of lice. When slowly burnt, the smoke may be utilized for the destruction of lice on plants in greenhouses or window gardens. In the form of a fine dust it is often effectual in ridding plants of flea-beetles, and in the form of dust or stems is probably the best remedy we have for woolly aphis on the roots of apple trees.

A decoction made by boiling tobacco dust or stems in water in the proportion of a pound to three or four gallons, is destructive to plant lice (Aphidæ) and to lice upon cattle. Tobacco, very finely powdered, in the form of snuff, may also be used dry against the same insects. It is best to first spray the insects with water.

24. Sulphur.

Every one knows of the use of sulphur fumes for the destruction of animal life. Sulphur is specially destructive to "red spiders" and "brown mites," and may be applied as flowers of sulphur, dry, through a blowgun of some sort, or mixed in soapy water or soap solutions in the proportion of an ounce to a gallon of the liquid and applied as a spray. The liquid must be kept thoroughly stirred, as the sulphur settles quickly.

25. Hot Water.

Water heated to 130 to 140 deg. F. kills very quickly any insect that is put into it, but is harmless to plants unless they are kept submerged for a long time. Lice, especially those on roots, may often be killed conveniently with hot water.

SUBSTANCES THAT KILL BY BEING INHALED.

There are two insecticides of this sort that are of special importance. As both are destructive to vegetable life also, care must be had in their use that they are not applied in strengths that will destroy the plants. It is important that tents, rooms, or other receptacles in which objects are placed for fumigation, be as nearly air tight as possible.

26. Carbon Bisulphide; "Fuma."

This is a clear, extremely volatile liquid with a very disagreeable odor unless obtained pure, when it is much more expensive. The fumes are heavier than air, so that it is always best to expose the liquid in the upper part of a building, or other receptacle containing objects to be treated. The fumes are explosive also when mixed with air, so that *great care must be taken not to bring fire near them.*

For the purpose of fumigating a building or other inclosed space containing growing plants, not over one pint of the liquid to 1,000 cubic feet of space should be used. For the destruction of insects in seeds, carpets, or clothing, it may be used much stronger.

To destroy ant hills, thrust a sharp stick down into the hill to a depth of eight or ten inches and then remove it and pour in two or three ounces of the carbon bisulphide; fill the hole with earth by stamping on it, and then throw over the hill a wet blanket to hold down the fumes. Allow the blanket to remain for a half hour at least, and the ants will be dead. If the hill is a very large one it would be well to make two or three holes for the carbon bisulphide.

To kill prairie dogs, pour three or four ounces of the liquid on a ball of cotton and roll the latter down the prairie dog hole and quickly fill the mouth of the hole with dirt. Dry horse droppings or pieces of gunny sacking may be used in place of the cotton.

For the destruction of the woolly-louse of the apple, thrust a crow-bar or other sharp instrument into the ground to the depth of one foot or a little more, and at a distance of two feet from the crown of the tree and upon three sides of the tree. In each of these holes pour one ounce of the carbon bisulphide and close the holes quickly with damp earth. This is a cheap and effectual remedy, and, if care is taken to have the holes made two feet from the tree and to have only about an ounce of the liquid put in a hole, there will be little or no danger of killing the trees.

This substance is expensive when purchased in small quantities at a drug store. It may be obtained quite cheaply if purchased in 50-pound lots, from Mr. Edward R. Taylor, Cleveland, Ohio. Write for prices.

27. Hydrocyanic Acid Gas.

This gas has come into very general use, particularly in the orange growing sections of the country, for the destruction of scale insects. It may also be used for the destruction of insects in mills and in dwellings and in closed receptacles generally. Some of the best nursery men have adopted the excellent plan of fumigating all their nursery stock with hydrocyanic acid gas before shipping to their customers. This should always be done.

The chemicals of which this gas is made are cheap and are used in the following proportions:

Potassium cyanide (of 98 per cent purity)	1 ounce
Commercial sulphuric acid	1 ounce
Water	3 ounces

The above quantities are sufficient for a space of 100 cubic feet for the fumigation of dormant trees and plants (nursery stock). It may be used in the same strength, or even stronger, for the fumigation of mills, houses, clothing, and the like.

The tent, building, or receptacle in which the fumigation is to take place, should be as tight as possible. The less wind there is the better, if the fumigating room is not very tight.

The gas should be generated in an earthen jar, or wooden bucket or tub. *The chemicals must be added in the following order:* First put in the water; then add the acid; and, after the water and acid have mixed, add the potassium cyanide. A good way to add the poison is to have it tied in a paper sack and placed upon a piece of board over the dish containing the acid and water, with a string attached to the sack and passing to the outside. Then, when everything has been made tight, a pull on the string will precipitate the sack of cyanide in the acid and a rapid escape of the poisonous fumes (HCN) will immediately take place, causing violent bubbling of the liquid. Filling one's lungs with these fumes would cause almost instant death, so great care must be taken not to breathe them. Fumigating rooms must be arranged so that doors or windows of some sort can be raised from the outside quickly. Then a thorough airing must take place before anyone enters.

It would require considerable space to give full directions for the fumigation of orchard trees, and, as there is little likelihood that such fumigation will be called for in Colorado for some time to come, I shall not take space to describe the process here. Those specially interested can obtain bulletins giving full directions from the Department of Agriculture, Division of Entomology, Washington, D. C. Full directions can also be obtained in a book entitled "Fumigation Methods," by W. G. Johnson, and published by the Orange Judd Company, New York.

SUBSTANCES THAT REPEL.

There are a number of substances that are more or less useful for the purpose of driving insects away from places where they would do harm if unmolested. I give below a few of the most important.

28. Naphthaline, Gum-Camphor, and Moth Balls.

Naphthaline crystals are much used in insect boxes and in boxes or trunks where furs, feathers, or woolen goods are kept, for the purpose of keeping out in-

sects that feed on these animal products. It is probably the best single chemical that can be used for this purpose. Gum-camphor is also much used for the same purpose and moth-balls are a combination of these two volatile substances. These materials cannot be used to kill insects, but only to repel them.

29. Tobacco.

Tobacco, in the form of dust, or otherwise, is often used for the same purpose as the preceding, but to be effectual must be used quite freely.

30. Ashes.

Ashes, particularly from wood, are frequently used to dust upon plants after a rain or while the dew is on and often result in the insects disappearing. Particularly is this true in case of flea-beetles and the cucumber beetle when feeding upon leaves. Ashes do not kill the insects, but they make the food distasteful, so the insects are driven to other plants.

31. Lime, Plaster, and Road Dust.

These substances are also used like ashes as repellents, but are of little or no use for the destruction of insects, except, possibly, the pear and cherry tree slugs.

INSECT TRAPS.

There are many methods of trapping and destroying insects. One of the most common is the use of bright lights exposed at night.

32. Lights.

The usual plan is to place a light over a dish of some sort that contains water with coal oil on top of it. Many night-flying insects are attracted by lights and may be destroyed by devices of this kind, but there are also many insects that fly at night that are not attracted by lights. Such an insect is the codling moth, though light traps are often recommended for its destruction. Among those insects that are readily attracted by lights might be mentioned the adults of the army worm, of the various cut-worms, the garden web-worms, the corn or boll-worm, and the beet-worms.

It is not infrequently the case that more of the beneficial insects are destroyed than of destructive species, and it is quite doubtful if lights are often of any great importance as a means of lessening the injury to crops by the destruction of insects.

33. Sweetened Water, Cider, Vinegar, etc.

Some insects are attracted in considerable numbers to such substances as the above, but it is very seldom that the benefit derived from them will pay for the trouble and expense of using them. Mr. David Brothers, of Edgewater, Col., reported excellent success capturing moths of the fruit-tree leaf-roller with weakened vinegar in pans in the orchard, and the codling moth is attracted to some extent to a mixture of molasses and vinegar placed in apple trees. The advantage of such baits for the capture of insects is usually greatly overestimated by those who use them.

34. Bandages.

Heavy cloth or paper bands placed about the trunks of apple trees are quite useful for the capture of the larvæ of the codling moth that are leaving the apples and going in search of a suitable place to spin their cocoons. Burlap bands are cheap and seem to be as good as any. The writer took 1,481 codling moth larvæ under a single burlap band one season. Old gunny sacks cut into strips serve as well as anything. The band should not be less than four inches wide and should be composed of three thicknesses of the cloth.

The bands should be wrapped loosely about the trunks, the ends overlapped and held in place by a single carpet tack pushed in with the thumb.

If used against the codling moth they should be removed once in a week or ten days for the purpose of killing all the worms and then replaced.

The bands should be placed on the trees about the 10th of June in the warmer parts of the State, and about the 20th of June in the northern parts.

Bands of paper or wire screen are sometimes wrapped about the entire trunk to prevent the entrance of borers.

35. Hopper-Dozers or Hopper-Pans.

For the purpose of catching jumping insects, especially grasshoppers, the hopper-dozer or hopper-pan is most useful. There are different methods of constructing these pans. A form used by Dr. Riley and described by him many years ago has been found very effective. The pan is entirely of sheet-iron, and is drawn across the field by two men or two horses. In the bottom of the pan is placed a small amount of water with kerosene on it. All grasshoppers that come in contact with the oil die. The back of the pan may be extended by means of stakes at the corners and a strip of cloth hung between them. Such an extension catches many grasshoppers that would otherwise escape. A modification of this pan is shown in bulletin No. 112 of this station by Mr. P. K. Blinn.

36. Sticky Substances.

Bandages of sticky substances, such as printer's ink, "Dendroline," "Raupenleim," "Tree Tangle-Foot" or even cotton batting, are sometimes used to prevent insects from climbing trees. Where oily substances are used it is safer to put them on a bandage of stout paper, which is then wrapped about the trunk of the tree.

THE APPLICATION OF INSECTICIDES.

I think it best not to attempt to show types of apparatus for the application of insecticides in this bulletin. There are so many manufacturers of spraying machinery now that it would be impossible to show pumps and other appliances made by more than a few of them. One who contemplates purchasing spraying apparatus should write to a few of these firms for catalogues, and then select what seems to be the pump or other machine that is best suited to his needs. Advertisements of many dealers in spraying machinery may be found in papers and magazines devoted to agricultural and horticultural pursuits.

APPLICATION OF DRY INSECTICIDES.

The upper surface of the leaves of all low plants can be easily treated with a dry insecticide by dusting it through a cheesecloth, or other thin muslin bag held in the hand. There are also various dust sprayers of large and small sizes upon the market.

By whatever means the dust is distributed it is best applied in the evening or early morning when foliage is slightly moistened with dew, or after a shower.

APPLICATION OF WET INSECTICIDES.

The Pumps.

Pumps with metal valves should be obtained for the application of insecticides or fungicides in liquid form, as the materials used harden or decompose leather valves so that they last but a short time. If the pump is to be used with a tank or barrel it is also important to have some kind of attachment that will keep the liquid agitated so the materials in suspension will not settle. A common error is to purchase a pump of too small capacity, because it is cheaper. A smaller, cheaper pump usually means less accomplished in a day with same help and a poorer job, with a greater expenditure of labor. And then, it is often important to complete the spraying in as short a time as possible after it is begun. To do this, a pump of large capacity with two or more leads of hose is necessary. The hose to which the nozzles are attached should be as light as possible and still have the requisite strength—a hose of good quality with heavy wall, but small caliber. Bucket pumps are sold by different dealers at prices ranging between about $2 and $8 in price. They are suitable for use among garden vegetables, shrubbery, and all low plants, but should not be purchased for orchard work if one has more than a very few trees to treat.

If one has light spraying to do and is without help, the compressed air sprayers are very convenient. Large compressed air sprayers that derive their power from gearing attached to the wagon wheel are specially adapted to the treatment of low plants, but I very much doubt if any spraying machines of this class upon the market are well adapted to the spraying of large orchard trees where the wagon must stand still a large proportion of the time while the spraying is going on.

Where large orchards are to be sprayed it is a matter of necessity and economy to use tanks that will hold 200 and 300 gallons, and pumps of large capacity. In such orchards gasoline power sprayers are most useful.

HOW TO SPRAY.

The first requisite for a good job of spraying is a pump that will give plenty of pressure in the hose. Then, if one has a good spraying nozzle and a liquid that is free from solid particles of a size to clog the sprayer, there will be no difficulty in getting a good spray. Barrels and tanks should always be filled through a strainer to avoid loss of time and annoyance through the clogging of nozzles.

A very fine spray is most economical of material and, for an even and thorough distribution, is best, and is specially useful for the destruction of caterpillars, slugs, and other insects that devour the foliage of plants. In case of the first spraying for the codling moth, however, I am still constrained to recommend as I have done for years, that the spray be a medium coarse one. By this I do not mean that the spray should be composed largely of large drops produced by the breaking up of a solid stream thrown forcibly into the air, and it should not be a fine mist or fog. A rather coarse Vermorel, or a good Bordeaux nozzle with a pressure of 100 or 125 pounds, will furnish such a spray as I refer to. When spraying is being done to destroy leaf-eating insects, care should be taken not to spray too long in one place, as this will result in the little drops that collect upon the leaves uniting and running off, carrying the poison with them. Here again this rule does not apply to the first treatment for the codling moth. In that application there should be but one end in view, and that to fill every blossom or calyx cup with the spray.

NOZZLES TO USE.

There are two types of nozzles that are used almost exclusively for the distribution of liquids. Perhaps the most popular among these are the Bordeaux and Seneca nozzles which throw a flat spray or a solid stream, and the Vermorel nozzles which throw a cone-shaped spray which may be graded from medium coarse to extremely fine, depending upon the pressure and the tip that is used upon the nozzle. It is a big advantage in nozzles of this class to have them joined to the connecting rod so they may be turned at any angle to the rod that is desired.

Any of these nozzles may be used singly or in batteries of two to four.

Protection Against Rust.—Metallic surfaces may be preserved by the simple application of paraffin oil; but it is better to make a solution of 100 parts of paraffin oil in 200 parts of benzine. The objects are immersed in this after being dried in hot air. They are stirred about in the solution, in order that the liquid may penetrate everywhere. They are afterward exposed for drying, in order that the benzine may be evaporated.—Chronique Industrielle.

UTILIZATION OF GAS FROM SUCTION PRODUCERS.

By DR. OSKAR NAGEL.

PRODUCER gas power plants are built for generating, outside of a suitable fuel, a mixture of carbon monoxide and hydrogen called "Dowson gas," which, if used in gas engines, allows an exceedingly advantageous utilization of the fuel. Up to a few years ago producer gas has been made almost exclusively in so-called pressure gas producers by evaporating water in a separate boiler and by leading the steam, mixed with air, by means of a steam blower or fan, through the glowing fuel whereby the steam is decomposed to hydrogen and the coal burned to carbon monoxide. This mixture of combustible gases is led through a scrubbing arrangement for removing the dust and tar, then through a gas holder for equalizing the fluctuations of the pressure, and from here to the engine.

It is evident from this description that for generating gas by this method a boiler and a gas holder are required, which entails considerable cost of construction and attendance, and requires also a large floor space. Another disadvantage of the pressure system is, that it cannot be installed inside the city limits as it is not without danger on account of the possible leakage of gas. It was, therefore, an object of inventive engineers to supplant this pressure system by a safe and simpler construction in which no stock of gas is kept on hand, and in which no leakage can possibly occur. This has been fulfilled by means of the so-called suction gas producer, in which the pressure is supplanted by the suction of the moving gas engine. The use of a boiler and a gas holder is done away with in this system, as the engine is sucking just as much air and steam through the fuel as to generate the necessary amount of gas for the work required. This type has been very well developed on the Continent, and is especially to be recommended for units up to 250 horse-power.

In a suction gas producer plant the boiler is supplanted by an evaporator which, in small plants, is built frequently on the top of the producer in the form of a water jacket, and in large plants close to the producer in the form of a tubular evaporator. This evaporator is generating the steam required by utilizing the waste heat of the producer and of the gas, which is of considerable advantage as compared to the old system, the firing of a separate boiler being dispensed with. The heat of the gases, respectively of the producer, is entirely sufficient for furnishing the quantity of steam required for the generation of an effective power gas.

The utilization of fuel in suction gas producers is higher than in pressure producers, and is reaching 80 per cent or more. The transformation of steam into hydrogen and the formation of carbon monoxide is taking place so quickly that the producer is always making the amount of gas required and is able to start suddenly from a low to a full load.

The advantages of a suction gas producer are: automatic generation of the gas by the engine; highest and best utilization of fuel; no boiler and no gas-holder are required; can be erected without danger in any convenient place; easy to start and to run; no soot, no smoke, no odor; no explosion possible; small floor space required.

A complete suction gas producer plant consists of a blower which up to 150 horse-power is driven by hand, a producer, an evaporator, an overflow water-pot, a scrubber, and a small equalizing tank. In plants above 75 horse-power a sawdust scrubber is advantageously inserted behind the wet scrubber, and in plants where two or more engines are fed from the same producer a small gas-holder with automatic regulation is used.

The producer consists of an iron shell lined with fire bricks and provided with a suitable hopper. The grate area according to the quality of fuel is 0.8 to 1 square foot for every 10 horse-power. The scrubber consists also of a sheet-iron shell and is filled preferably with broken coke. If a good quality of fuel is used, the scrubber has to have a capacity of at least 1 cubic foot for every horse-power.

Before starting the engine the fuel in the producer has to be heated up by means of a blower until the gas is burning well on the test cock. When this point is reached the blower is stopped and the engine started in the usual way. The engine is now drawing by her own sucking action the necessary amount of air and steam through the fuel, and is producing her own power gas.

From the producer the gas is drawn through the scrubber and the equalizing tank to the engine. The gas-making process continues as long as the engine is moving, but as soon as the engine is stopped the gas making is also stopped.

Anthracite, charcoal, or coke can be used equally as well for generating gas in a suction gas producer. It will take, according to the ash content, 1 to 1¼ pounds of anthracite or charcoal, or 1¼ to 1 1-3 pounds of coke for developing 1 horse-power hour. With anthracite (pea) at $5 per ton, 1 horse-power hour will cost about one-quarter of a cent. This is about one-sixth the cost of illuminating gas power at a price of 75 cents per 1,000 cubic feet of gas, or one-eighth the cost of gasoline power, figuring gasoline at 16 cents per gallon.

An ordinary illuminating gas engine has to undergo some slight changes before it can be used for producer gas. The compression has to be increased to at least 105 pounds and the ratio of gas to air has to be arranged 1 : 1¼. The gas inlet has to be increased, and the air inlet decreased to the ratio above named.

A NEW THEORY OF ERECT VISION.

By ABBÉ NOGUIER DE MALIJAY.

THE optical system of the human eye, consisting of the cornea and the crystalline lens, forms on the retina real and inverted images of objects in the field of view. How, then, are these images re-inverted in the brain? In other words, why do not all objects appear inverted?

This problem appears to have been first attacked, in 1604, by Kepler, whose explanation is that in the transmission of the image to the brain each point is referred back to the point of the object, on the opposite side of the axis of vision, of which it is the optical image, so that the whole image is re-inverted in the art of perception.

This theory has been accepted by the most cele-

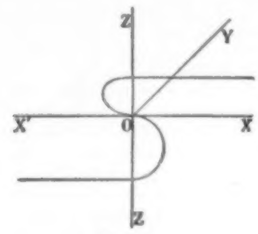


Fig. 1.

brated of the early physicists—Scheiner, Descartes, Leibnitz, Newton, Euler, D'Alembert, Arago, etc., and by most modern writers on optics. Some scientists, however, regard such re-inversion as unnecessary, and attribute erect vision to a habit acquired in infancy, of mentally reinverting the images of objects which are really seen inverted.

For the objective and external fact and the subjective physiological and psychical phenomena of its perception are essentially different things.

"After the rays of light have impressed the nerve terminations in the retina," says Dr. Trouessart, "we have no longer to consider their direction, with regard to the nerve fibers, but only their arrangement, and the resultant judgment of the relative position of objects is not necessary or immediate but is the effect of habit."

According to this theory, the eye and the brain must be educated to perform this re-inversion of the retinal image. Therefore it becomes difficult to admit

Fig. 2.

this explanation of erect vision in view of the well-known fact that a newly-born infant directs its glance instantly and unerringly to a bright object, looking up, down, to right or left in accordance with the real position of the object, instead of directing its eyes toward the opposite part of the field of view, as the theory would require.

A very different theory, based on positive anatomical facts, has been enunciated by M. Georges Poullain, a non-professional student of ophthalmology. The study of recent discoveries in the anatomy of the nervous centers and the comparison of sections of the optic nerve in different planes revealed to M. Poullain the existence of a loop or twist in this nerve in the pulvinar, or protuberance of the outer and posterior part of the optical layer of the brain. This peculiar conformation, as we shall see, explains very satisfactorily the re-inversion of the retinal image. The optic nerves, after emerging from the eyeballs, converge to the optic chiasm where they partly cross, or exchange part of their component fibers. The two nerve-bundles,

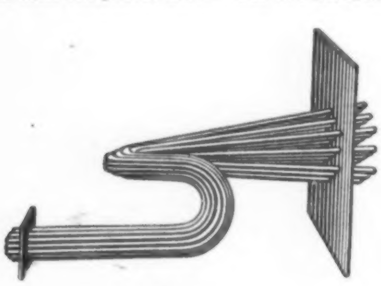


Fig. 3.

thus modified, separate and pass around the peduncles. In this part of their course they are known as the optical bands, or Grasset's hemiopic nerves. These bands enter the brain and their fibers can be traced in the pulvinar, where they describe concentric curves, and in other positions of the optical layer, where they are known as Gratiolet's optic rays.

In order to determine accurately the complicated path of the fibers Poullain has studied and measured sections of the loop made by a horizontal plane and by two vertical planes, anterior, posterior, and transverse. By combining the results he found that each fiber could be represented by a curve in space composed of two curves in mutually perpendicular planes connected by a short rectilinear element lying in the intersection of those planes (Fig. 1).

The first component curve lies in the vertical plane $XOX'Z'$, the second in the horizontal plane $X'OXY$, and the connecting element is situated at O in the line XX'. The bundle of closely-packed and parallel fibers describes a curve similar to that formed by each of the individual fibers.

This discovery makes it easy to understand the mechanism of the re-inversion of the retinal image, as the double curve effects a complete reversal of the order of the nerve-fibers, both from top to bottom and from right to left, the two half-turns being exactly equivalent to a half-twist, or rotation through 180 deg. about the axis of the bundle.

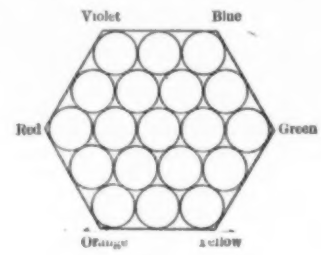


FIG. 4.

This may be shown by bending a metal rod of rectangular section into the form assumed by the optic nerve (Fig. 2). If we suppose the rod to be composed of parallel fibers and trace the course of each fiber, beginning at the left, we see that each element of the upper surface passes to the bottom in tracing the first, or vertical, curve and remains at the bottom thenceforth and that each element of the front surface remains in front until it reaches the second, or horizontal curve, in traversing which it passes to the back. The final result, therefore, is the same as if the rod had been twisted through two right angles.

M. Poullain observes that this complicated course of the optic nerve must have a purpose and that this purpose is obviously the reinversion of the retinal image. The twisted path of the nerve fibers may be illustrated still better by the model shown in Fig. 3, in which the 500,000 nerve fibers are represented by

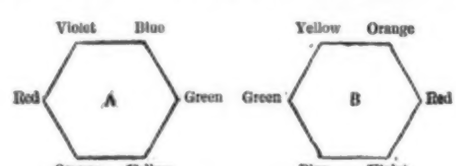


FIG. 5.

19 wires arranged in the form of a hexagonal prism, of which Fig. 4 shows the cross section and the distinctive colors given, in the order of the solar spectrum, to the 6 wires which occupy the angles of the hexagon. By following the paths of the wires through the double curve it will be seen that if the arrangement at the left end is represented by A, the arrangement at the right end will be represented by B (Fig. 5), the bundle of wires having, practically, been twisted through two right angles.

The most convincing illustration, however, is obtained by threading a picture of a building or other object on a system of two wires of different diameters which are soldered together lengthwise (Fig. 6). The wires having been bent in the double curve of the optic nerve, the picture, the hole in which closely fits the wires, is moved along them and is seen to become inverted in traversing the double curve. At the left end of the wires the picture represents the retinal image; at the right, the cerebral image.

Poullain has also studied the course of the optic nerve in birds, which he finds to be similar to the path of the human nerve but still more complex.

The new theory of erect vision, based on anatomical

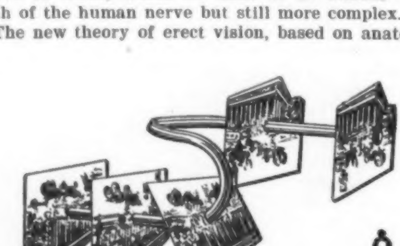


Fig. 6.

facts and logical deductions therefrom, appears destined to replace the old, unsatisfactory and unsubstantiated hypotheses.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Cosmos.

A new record in tonnage will be created by the launch of the liner "Adriatic" for the White Star Line from the Belfast shipyard of Messrs. Harland & Wolff. The "Adriatic," though not so long as the "Baltic" of the same line, and which is at present the largest vessel in the world, will, however, be 1,124 tons heavier. The vessel is 710½ feet in length, beam 75 feet, depth 50 feet, and is of 25,000 tons.

A METHODICAL EXPERIMENTAL STUDY OF THE AEROPLANE.

By VICTOR TATIN.

IN my opinion the problem of mechanical flight cannot be solved by calculations alone, as in this unexplored field of research experience cannot fail to indicate hitherto unsuspected factors which in turn must form the basis of new calculations and experiments, and so on. This systematic and scientific procedure, which I have always followed, will lead us infallibly to the desired result.

In this article I give in detail the reasons which have led me to oppose the construction of crude and imperfectly studied apparatus which can only advance the progress of aviation with disheartening slowness, and I suggest a better way than the one along which we are now plodding.

From a rather obstinate infatuation for machines with moving wings, constructed in imitation of birds, I have been converted by experience to the cause of the aeroplane. If the results which I obtained with winged flying machines have attracted some little attention the reason is that I actually succeeded in making a few little models fly fairly well with an expenditure of power which, though excessively great, was still very much less than had been found necessary in earlier apparatus of the same type. I constructed a long series of models of insects and birds, of natural size and weight, from the dragon fly to the pigeon, but when I attempted to go further and imitate the eagle I failed completely. It is true that in the small models the motive power was furnished by India-rubber bands which allowed a great deal of energy to be expended in a very short time, while compressed air motors were employed in the experiments with larger models. With this type of motor it is possible to measure exactly the expenditure of energy and I found that even 10 kilogramme-meters per second for each kilogramme of the weight of the machine (33 foot-pounds per second, or about 1-16 horse-power, for each pound) was insufficient for flight. This result proved that practical success could not be hoped for with winged machines, and thenceforth I devoted my attention entirely to the aeroplane.

The first fairly successful aeroplane was constructed in 1871 by A. Pénaud. It was very small, weighing only half an ounce, and was driven by an India-rubber band. If larger machines were made on the same model, they were probably failures, for we have no record of them.

I proposed, then, to begin with Pénaud's experiment, improve it if possible, analyze it to the best of my ability, and, with the data obtained from these preliminary experiments, construct a larger machine which, on experiment and analysis, should furnish data for the construction of a still larger one, and so on until I should have an apparatus large enough to bear a man's weight.

The best type of machine, evidently, is that which requires the least expenditure of energy in proportion to the total weight transported, and with which the greatest speed can be obtained. It becomes necessary, therefore, first to seek the causes that limit the speed of a given apparatus of given power and then to take account of the mode of application of that power in order to introduce improvements conducive to higher efficiency. This analysis will comprise three principal parts. First, we have to calculate the power necessary to keep the machine afloat; that is to say, the work performed against the horizontal component of the air pressure experienced by the lower surface of the supporting aeroplane when its inclination and velocity are such that the weight of the entire apparatus is borne by the air.

In the second place, we must determine the loss of energy due to the forward movement of the whole apparatus, regarded as a projectile, through the air. This can be obtained to a sufficiently close approximation, when the area of the projection of the machine on a plane perpendicular to the line of flight is known, by applying the known laws of resistance of fluids with the proper coefficient of resistance for each part of the apparatus, for the great diversity in form of these parts causes corresponding differences in the ease with which they traverse the air.

Finally, by subtracting the sum of the two quantities thus obtained, the work of support and the work lost through displacement resistance, from the total work employed in propulsion, we obtain the amount of energy consumed in overcoming the skin friction between the air and the moving surfaces.

By "the total work employed in propulsion" I do not mean the whole work of the motor, but something less than this by the losses due to gearing and inefficiency of the propellers. The discussion of these losses seems to belong to general mechanics rather than to aviation, but I shall mention later the effect of the slip of the propeller.

Pénaud's ingenious little machine (Fig. 1) was very light in proportion to its size, weighing only about half an ounce, though the axis or frame was 20 inches long and the aeroplane had a breadth of 18 inches and an average length of 4½ inches. Lateral stability was assured by the curvature of the aeroplane, the transverse vertical section of which was nearly a semi-ellipse with the major axis horizontal and the convexity directed downward. I have never found a form more favorable than this to lateral stability. It may require a slightly greater area than would be absolutely necessary if some other form were adopted, but this slight disadvantage is abundantly compensated by its perfect security in respect to stability. This supporting aeroplane was attached to the middle of

the axis, at the after end of which was a horizontal rudder of precisely similar form with its after edge slightly raised to insure horizontal equilibrium. The forward end of the axis carried a screw propeller 8½ inches in diameter which was driven by twisted bands of India rubber running the entire length of the axis. This rudely fashioned propeller was relatively very large and its pitch—too long in my opinion—was nearly 13 inches. One is led to ask why a screw of this diameter and pitch did not overturn the little machine, especially as the reaction torque must have been very great because of the enormous slip of the propeller and the large angle which its blades made with their direction of motion. Pénaud does not mention this difficulty, but I am confident that he obviated it by weighting one side of the aeroplane. I have employed this simple expedient which always prevented capsizing, though it did not always prevent extensive and alarming oscillations. It would be much better to employ two propellers, turning in opposite directions, but this arrangement would be too complicated for such small machines.

I made several little machines similar to Pénaud's, though in some of them I employed a rectangular, in place of the approximately diamond-shaped aeroplane. I also increased the dimensions until the weight exceeded two ounces. I found, however, that these small models were ill adapted for the purpose of exact research, as the results of different experiments were contradictory. Possibly Pénaud's experiments were more exact and less discordant than mine. At all events, he published an analysis of them which may be summarized as follows: The twisted India-rubber band developed a power of 32.8 gramme-meters (0.24 foot-pound) per second, of which 6.1 gramme-meters (0.045 foot-pound) constituted the work of support T, calculated by the formula $T = P\,V \sin a$, where P is the total weight of the machine, V its speed, and a the angle between the planes and the direction of motion. The losses due to the slip of the propeller and its friction against the air were estimated to amount to 19.7 gramme-meters (0.140 foot-pound) per second, a value which apears enormous, as it is equal to 60 per cent of the total energy. The sum of these two quantities, the work of support and the loss at the screw, was $6.1 + 19.7 = 25.8$ gramme-meters (0.189 foot-pound) which, subtracted from the total energy, leaves $32.8 - 25.8 = 7$ gramme-meters (0.050 foot-pound) per second, or about 21 per cent of the total energy, for the work of translation, expended in overcoming displacement resistance and skin friction.

Although my own results were so uncertain that I do not quote them, they seemed better than these inasmuch as the loss at the screw was always less. On the other hand, more work was consumed in overcoming air resistance, probably because Pénaud's aeroplanes were made of thin, stiff cardboard and mine of silk stretched over frames of rattan or reeds. The resistance was increased by the bending of the aeroplanes, the thickness of the frames, and the grain of the silk, but the superior efficiency of my propellers more than counterbalanced these defects and produced, on the whole, results slightly better than Pénaud's.

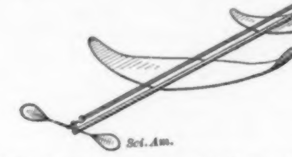
The only useful deductions that can be drawn from experiments with these small models are that only about one-fifth of the whole power is used in supporting the machine in the air and the rest is lost through defects of construction. Besides, the small speed obtainable, 3 or 4 meters (10 to 13 feet) per second, is scarcely comparable with the speed with which a practical flying machine should move. On the other hand the relation of weight to power, 37.5 kilogrammes (82.5 pounds) per (French) horse-power appears, at first sight, astonishingly favorable, but it is explained by the small speed, for though the work of support and the loss at the screw are directly proportional to the velocity, up to a certain point, the work of translation is proportional to the cube of the velocity, as in all cases of the motion of a solid through a fluid. It is evident, therefore, that an enormous increase in power would be required to effect a comparatively small increase in speed, and the direction in which improvement should be sought is clearly indicated.

I decided, therefore, to construct an apparatus of such dimensions that the speed, the power, and the manner of its distribution could be more easily determined, to endeavor to increase the speed and to employ a compressed-air motor. The body of the new machine (Figs. 2 and 3) was a pointed steel cylinder, which contained about two gallons of air at about 90 pounds' pressure. The aeroplanes were made of fine-grained silk taffeta on frames of rattan, for which reed frames, somewhat heavier but stiffer, were afterward substituted. The two aeroplanes, one on each side, met at a very obtuse angle with its apex below. Their combined width was about 6 feet, their total area about 8 square feet, their usual inclination to the direction of motion 7 degrees. There was also a tail of the general shape of a bird's. On top of the air chamber were placed the manometer, valves, etc., and the motor. At the sides, in front of the aeroplanes, were the two propellers, revolving in opposite directions, each 16 inches in diameter, and with a pitch of 18 inches. The whole apparatus was mounted on a three-wheeled car which enabled it to run along the ground. The total weight, including the car and the compressed air, was a little less than 4 pounds.

The trials took place on a circular wooden track 46 feet in diameter, to the center of which the machine was attached by a cord. When the valve was opened the machine started, ran around the track with gradually increasing velocity and at a speed of about 26 feet per second, rose and continued its circular course in the air.

The motive power was measured with a very sensitive dynamometer devised expressly for these experiments which showed a traction of 0.715 pound on the shafts of the propellers when they were making 22 revolutions per second, corresponding to a movement of 33 feet by a solid screw. The work done in each second was, therefore, $0.715 \times 33 = 23.7$ foot-pounds.

As the actual velocity, however, was only 26.4 feet per second, it is evident that the effective work was



PÉNAUD'S SMALL AEROPLANE, 1871.

diminished by 20 per cent, or to 19 foot-pounds, by the slip of the propellers.

The improvement in efficiency of propellers over the little models driven by India-rubber bands is very apparent, but the loss is still too great, and we shall see that it can be diminished.

The distribution of energy may be calculated as follows: For the work of support we have, as before, $T = P\,V \sin a = 3.85 \times 26.4 \times 0.13 = 13.2$ foot-pounds per second. This quantity, subtracted from the 19 foot-pounds of available work, gives 5.8 foot-pounds, or 31 per cent, for the work of translation.

This is greater than the work of translation of Pénaud's aeroplane, but the speed of the new machine is more than twice that of Pénaud's. To double the speed of Pénaud's little machine it would be necessary to multiply the work of translation by the cube of 2, or 8.

But when the analysis of the compressed-air machine is pushed further it is seen to have the same defect as the other in kind if not in degree, for a speed of 26 feet per second would be useless in practice. So low a speed would necessitate the employment of

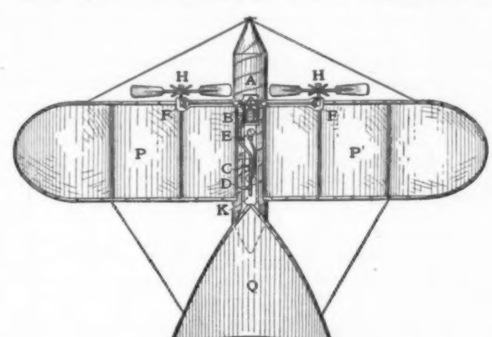


Fig. 2.—PLAN VIEW OF COMPRESSED AIR AEROPLANE.

A, receptacle; B, engine; C, cock; D, cock; E, pressure gage; F F′, bevel gears; H H, propellers; K, connecting pipe for charging tanks; P, P′, planes; Q, rudder.

larger aeroplanes than could well be constructed, for in this example two square feet of bearing surface are required for each pound of total weight. In another respect the experiment appeared very encouraging, for it was the first instance in which an aeroplane actually flew with a weight of nearly 100 pounds per horse-power. The analysis is not yet complete, for we have not separated the skin friction from the losses due to the defects of the machine, regarded as a projectile. Finding this problem too complex for solution, I contented myself with the conclusion that the only way to reduce to a minimum the displacement resistance is to inclose the machine and its appendages in an envelope so as to form a single projectile, narrow, elongated, and as free from protuberances as possible, and I adopted this rational plan in my next machine, which I constructed in collaboration with Prof. Richet.

This machine (Fig. 4) was much larger and heavier than the preceding. The body, of square cross section and with pointed ends, was 10 feet long and 16 inches wide and deep. It was formed of four thin pine boards. To the sides, at the top, were attached two trapezoidal aeroplanes with their outer edges slightly raised. The extreme breadth, including the width of the body, was 22 feet. The area of the aeroplanes was 88 square feet and the angle which they made with the direction of flight was less than 3 degrees. The propellers, which revolved in opposite directions, were placed at the ends of the long, narrow body. Their diameter was 33½ inches, their pitch 50 inches. This pitch was very long in proportion to the diameter, but we thought it justified by the small

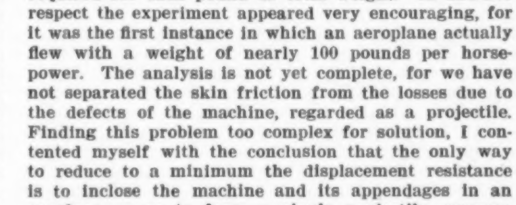


Fig. 3.—COMPRESSED AIR AEROPLANE, SIDE VIEW.

displacement resistance, and desirable because it enabled us to avoid excessive speed in the motor, which was keyed directly to one of the propeller shafts and connected by a gearing to the other. The tail, behind the stern propeller, had a surface of 22 square feet. Its function was to keep the flight horizontal and the inclination of the aeroplanes constant.

The motor was a steam engine with a single cylinder and a cut-off of about one-third, which we succeeded, though not without difficulty, in stowing with its boiler in the narrow body of the vehicle. The engine, boiler, furnace, and accessories weighed 24 pounds; the entire machine ready for flight with a supply of coal and water weighed 72 pounds. The engine could develop 2 horse-power with a pressure of 96 pounds and a speed of 1,000 revolutions per minute, but we drove it at a slightly lower speed under a pressure of about 90 pounds, and developed about 900 foot-pounds per second.

The mechanical work available for propulsion was measured directly by attaching to the apparatus a

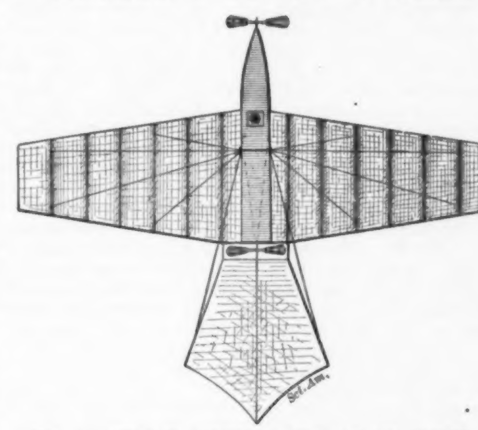


Fig. 4.—STEAM AEROPLANE, PLAN VIEW.

small dynamometer, which indicated a pull of 11 pounds when the propellers were making about 16 revolutions per second. As the pitch of the propellers was 4.22 feet, the travel per second of a solid screw of their pitch and speed of rotation would have been $4.22 \times 16 = 67.5$ feet, which, multiplied by the traction, 11 pounds, gives 742.7 foot-pounds for the work available for propulsion. The waste of energy by the propellers and their gearing was therefore less than 20 per cent, a result that could scarcely be improved.

For the trials of this apparatus, it was mounted on a wheeled carriage running on rails, of which the first section was inclined and the second horizontal. The second section terminated at the seashore, 33 feet above the water. On arriving at this point the weighted carriage was automatically detached from the aeroplane and fell into the water while the aeroplane was launched in the air. From the shore the machine appeared to fly in a perfectly straight and slightly ascending course. In the first trial, after traveling about 300 feet, it turned so that it pointed distinctly upward, and thenceforth proceeded more slowly. Finally, it turned to one side as if about to return to the starting point, but struck the water and sank before it could regain the speed required to support

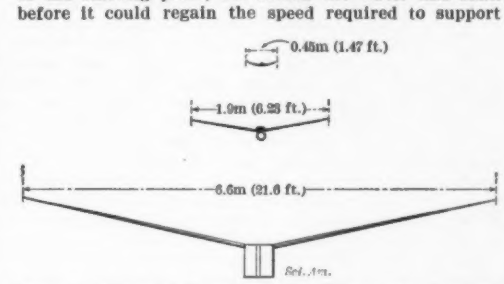


Fig. 5.—RELATIVE SIZES OF THE APPARATUS DESCRIBED.

it in the air. This result was evidently due to the small size of the tail, which, in this instance, measured only 11 square feet.

Two other experiments were made with a tail of 22 square feet, and the results proved that we were proceeding in the right way to obtain *automatic* equilibrium—for the problem of equilibrium of a manned aeroplane may be regarded as solved, if the machine is properly designed. In the second and third trials the course of the machine was entirely similar to the course taken in the first trial, except that the flight was extended to 460 feet. The tail was still either too short or too sharply inclined to the aeroplanes, but it was apparent to all the observers that, if the machine had been manned, a slight deflection of the tail would have brought the machine back easily and certainly to the proper position, for the trajectory was a curve of large radius, concave above.

Aside from this point, the results of the trial may be expressed as follows: With comparatively small power we succeeded in causing a machine weighing 72.5 pounds (the heaviest that had flown at that time) to fly at a mean speed of 58 feet per second, which is, I think, the greatest speed yet attained. Automatic equilibrium could evidently have been obtained by the adoption of a few changes. The slip of the propellers is the difference between 67.5 feet, the travel of the

hypothetical solid screw, and 57.75 feet, the average distance actually traversed by the machine in one second. The loss of power due to the slip of the propellers was therefore about 15 per cent and the power actually used in propulsion was reduced to 635.2 foot-pounds per second. The part of this required for support was $T = P V \sin a = 72.6 \times 57.75 \times 0.05 = 209.6$ foot-pounds per second. The work of translation used in overcoming displacement resistance can be computed approximately because the simple form of the machine makes it possible to calculate the area of its projection on a plane perpendicular to the line of motion. The result is 158.8 foot-pounds per second. The sum of this quantity and the work of support, 209.6 foot-pounds, is 368.4 foot-pounds, the subtraction of which from the 635.2 foot-pounds actually used in propulsion, leaves 266.8 foot-pounds per second, which can only have been consumed in overcoming skin friction.

In this apparatus the propeller efficiency is not far below the maximum obtainable, and the correct shape of the machine, regarded as a projectile, makes possible a speed almost great enough for practical aviation. In a larger machine the body could be still smaller, relatively, and thus a further increase in speed or economy in power could be effected. Finally, in these experiments the weight lifted amounted to 55 pounds for each horse-power actually employed in propulsion or 44 pounds for each horse-power developed by the motor, including loss in transmission and by air friction on the propellers.

To return to the question of skin friction: This is not quite analogous with friction between two solids, the inequalities of which cannot interlock without rupture or arrest of the motion. The air, on the contrary, necessarily penetrates into the intervals between the projections of the moving solid, so that these projections may be regarded as additional small moving bodies, or projectiles, rigidly attached to the main body. The resistance which the air opposes to their motion is, therefore, proportional to the square, and the power consumed by that resistance is proportional to the cube of the speed of the machine. This theory explains why the friction is so great and indicates that the way to make it smaller is to make the surface as smooth as possible.

Every part of our apparatus was covered with Chinese pongee silk, tightly stretched and unwrinkled, but not varnished. This fabric has a coarse and irregular texture and a distinct nap, and I am confident that the employment of a perfectly smooth silk tissue would have reduced the friction by about two-thirds.

It is evident that the systematic method of research which we have adopted involves little risk of failure. It may be necessary to make some use of the method of trial and error in passing from these machines to others large enough to be manned, but I have proved, I think, that the systematic method indicates the direction in which success is to be sought (Fig. 5).—Translated for the Scientific American Supplement from L'Aérophile.

SOME ASTRONOMICAL CONSEQUENCES OF THE PRESSURE OF LIGHT.

Just a year ago Prof. E. F. Nichols demonstrated in the Royal Institution that a beam of light presses against any surface upon which it falls, and now Prof. J. H. Poynting, D.Sc., F.R.S., of Birmingham University, shows some astronomical consequences of this pressure. We may have to wait a long time for convincing proofs of the effects of the radiation pressure in the universe, just as the experimental verification of the pressure itself was only accomplished after two centuries of failures. On the emanation or corpuscular theory of light a mechanical pressure seemed natural; but it was in vain looked for, and could not have been detected with the experimental means at the disposal of the eighteenth century. On the undulatory theory of light a radiation pressure is less obvious, but it was understood by Euler, in 1746, as a general consequence of wave motion, and suggested by him in order to explain the formation of comets' tails by repulsion from the sun, with which Kepler had already connected it. The general character of the problem was forgotten, and when Maxwell predicted the existence of the pressure in his electromagnetic theory of light, the pressure appeared only as a consequence of the particular electromagnetic waves. It may be of interest to our readers that, as Prof. Poynting has stated on another occasion,* Mr. S. Tolver Preston was probably the first modern scientist who, in 1876, calculated the energy-carrying power of a beam of sunlight without any assumption as to the particular nature of wave motion. The mathematical deduction of the general radiation pressure was given by Prof. Larmor in 1900. The final verification of the light pressure, in 1901, by Lebedew, of Moscow, and by Nichols and Hull, of Hanover, New Hampshire, U. S. A., has been explained to our readers.

The classical researches, particularly of Nichols and Hull, Prof. Poynting said, in introducing his subject, proved that the pressure of light per square centimeter of the beam was equal to the energy per cubic centimeter, or to the energy density of the beam. Of negligible importance in terrestrial affairs, this pressure became important in celestial regions, where it was ever exerting its force, without interruption, and particularly for the very minute members of our system. Nichols himself had described in his discourse how, if we imagined something like an explosion to take place in the comet when near the sun, the radiation pressure would push the scattered dust back from the sun, and that we might account for the formation of the tails of comets in this way. He showed that the pressure would still influence bodies, small but vastly greater than Nichols's dust, of which we had plenty in our system—the shooting-stars, for instance. In considering this problem we have to bear in mind that visible light only formed one of the octaves of the radiations from the extreme red to the extreme violet.

Theory and experiment justify the conclusion that when a source was pouring out waves, it is pouring out momentum as well as energy, the momentum passing per second through unit area of the cross-section of the beam being equal to the energy density in the beam. A beam of light carries with it momentum, manifesting itself as a forward pressure against any surface on which it impinged, and further as a back pressure against the source. If A (Fig. 1) represents a temporary source of radiation, C D the limited train of waves emitted, and B any opposing surface, then B would feel a push as soon as D had come up to B; and that push would continue until C had reached B. The waves thus behaved like a train of corpuscles or of bullets, which gave up their momentum to B.

The back pressure against A has not yet been demonstrated directly, but it can be deduced from the observations of Nichols and Hull that the pressure is doubled when there is total reflection, instead of total absorption, on the surface; and the safety of the argument that a beam carries momentum with it is supported by experiments which Prof. Poynting and Dr. G. Barlow have been making. If an oblique incident beam is totally absorbed, the momentum disappears as light momentum. But we can resolve the momentum into two components; one at right angles to B, representing the pressure, and the other a tangential push along B, which ought to become visible if B is enabled to slide in its plane. This Prof. Poynting has proved with the aid of a little apparatus. Two disks of glass, each about 3 square centimeters in area, one silvered, the other lamp-blacked, are fixed to a rod, 5 centimeters in length, as indicated in Figs. 2 and 3, and suspended by means of a cradle and a fine quartz thread, attached to the middle of the rod, the whole being contained in a vacuum of about 2 centimeters of mercury—the vacuum which Nichols and Hull found most suitable. If light falls under 45 deg. on the

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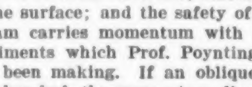


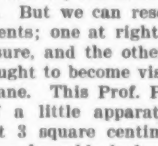
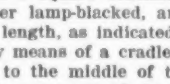
Fig.2.


Fig.3.


blackened disk B, the system is pushed back a little and also turned round by the tangential pressure, and the movements will be the same as if a jet of water were directed against B. The apparatus has to be adjusted most accurately, with the disks perpendicular to the rod, and symmetrical; otherwise convection currents and the Crookes radiometer may have a turning effect greater than the tangential pressure. But these heat effects take time to develop, while light acts instantaneously, and the deflections observed during the first few seconds have always been of the right direction and order. The objection has been raised that the normal force on any projecting granules of the blackened surface would produce an apparent tangential effect; but glass surfaces blackened at the back, and therefore smooth, behaved exactly like rough surfaces, and further experiments seemed to disprove the objection. A disk of mica was suspended horizontally by a thread attached to its center. Light falling upon the disk obliquely from the left would tend to turn it to the right; but heating effects would have contributed largely to the observed effect. When, however, the beam was made to strike from the right, the tangential push would be reversed, and the now observed deflection should differ from the previous value by twice the tangential push, and that had fairly been confirmed. In another experiment two small glass prisms were attached to the ends of a fine torsion arm of brass, 3 centimeters in length, with the refracting vertical end turned in opposite ways. If a beam of light was passed through the system, it would leave parallel to its incidence, but would be shifted, and the line of momentum would also be shifted parallel to itself. Thus a couple would be produced which would turn the system in the same direction as a water-jet would. In this and similar experiments the simple relations would, however, be complicated by pressures occurring at reflections and refractions.

Prof. Poynting explained how the momentum received or emitted by a surface would be modified when the surface was moving. If we imagined B in Fig. 1 to have moved with the velocity u up to D, while the light wave had traveled in the opposite direction to D with the velocity U, then B would receive in one second the momentum in length $U \times u$, instead of that in length u, and the pressure would be greater than if B were at rest by the fraction u/V, i. e., velocity of surface over the velocity of light. This might be called the Doppler reception effect. If the source of light were itself moving, we should have an analogous Doppler emission effect, which could be calculated. If we assumed that the amplitude of the waves emitted depended only on the temperature of the radiating body, and not on its motion, the motion would crowd up and shorten the waves in front of the moving surface, and would draw out and lengthen the waves sent out behind. More momentum would be put into the front waves per second, less into those behind. It could be shown that if the velocity of the source u were small compared with U, the velocity of light, the pressure was increased in the one case, and decreased in the other, by practically the same fraction u/U, as in the Doppler reception case. The rate of radiation of a black body depended, according to the Stefan-Wien law, upon the fourth power of its absolute temperatures. In the following table Prof. Poynting gave, in column I., absolute temperatures in deg. C.; in column II. the corresponding radiated energy in ergs per square centimeter per second; in column III. the resulting back pressure in dynes per square centimeter:

	I.	II.	III.
	0	0	0
Earth	300	4.3×10^4	9.6×10^{-6}
Sun	6000	6.7×10^9	1.5

Thus the back pressure on our earth, if painted black, due to its own radiation, at the average absolute temperature of about 300 deg. C., would be 0.0001 milligramme per square centimeter, and on the sun 1.5 milligrammes. The temperature of a small body in our system depended upon its distance from the sun. For a particle at the distance of our earth from the sun, the sun would occupy $\frac{1}{200{,}000}$ part of the sky. The particle would, therefore, receive and give out $\frac{1}{200{,}000}$ part of the radiation which it would receive and give out if the sun were all round it, when its temperature would be that of the sun. According to the fourth power law, its actual temperature would be $\sqrt[4]{200{,}000}$, or 21 times less than that of the sun. Now the temperature of the earth's surface, about 300 deg. C. absolute, was pretty nearly the same as that which a small black particle would have, and that gave for the sun a temperature of 21×300, or about 6,000 deg. absolute, in agreement with other estimates. The temperature also varied inversely as the square root of the distance; hence a particle within the orbit of Mercury, a fourth of the earth's distance, should have a temperature of 600 deg. (that of boiling mercury); out near Jupiter, at four times the distance, a temperature of 150 deg.; and near Uranus, of 75 deg. C. absolute (about that of liquid air). These data we needed for estimating the consequences of the pressure of light.

The direct result of the pressure by the sunlight was a lessening of the gravitation pull. As our atmosphere absorbed a considerable amount of the solar radiation energy, all calculations should be made for bodies outside the limits of our atmosphere. There the light pressure would be 0.6 milligramme per square meter, and on the whole earth the pressure would not amount to more than 75,000 tons, while the gravitation pull by the sun would be 40 billion times greater—3×10^{19} tons. But when we halved the radius of the sphere the mass would be reduced to one-eighth, while the area and the light pressure would be reduced to one-fourth only. Thus the ratio of the light pressure to gravitation would be doubled if we halved the radius, and this applied as well to the emitting as to the receiving body. If the radius of either the earth or the sun were reduced to 1-40 billionth of its value, the light pressure would equal the gravitation pull. If the sizes of both were reduced, a balance would be reached much sooner. Whether scattered meteorites would draw nearer to one another, or recede from one another, or not disturb one another at all, depended upon their mass, density, and temperature. Two bodies, each of the temperature and density of our sun, would be balanced for light pressure and gravitation pull if they were at a great distance apart and had each a diameter of 40 yards. Scattered meteorites 2 centimeters in diameter, of earth density, and at earth's distance from the sun, would tend to draw together; if of smaller size, they would repel one another; if nearer the sun, the light pressure would exceed the gravitation pull. If we supposed Saturn to be still a hot body at a temperature of 600 deg. C. absolute, and surrounded by a cloud of satellites, one-sixteenth of whose sky would be occupied by Saturn, those satellites would assume a temperature of 300 deg. (half that of their planet), and the satellites would not disturb one another at all, if about 2 centimeters in diameter, and of the earth's density. For a particle 0.001 inch in diameter, of the density of the earth, at the distance of the earth, the radiation push would be 0.01 of the gravitation pull, or the sun's mass would, as far as this small body was concerned, only appear to be 0.99 of what it was for the earth. That small body would therefore be retarded, and its year would have 367 (instead of 365¼) days. Then the Doppler emission effect would come in; it was only small—not more than $u/3U$ of the direct sun pressure; but it acted continuously, and, increasing the pressure on the advancing hemisphere, it would hinder the forward motion and deprive the body of some of its energy. As a result the body would fall in (be drawn nearer the sun) by 800 miles

* See Proceedings of the Physical Society, vol. xix., p. 476.

during the first year. In the second year it would become hotter, being nearer the sun, and would fall in still more; and that would continue and the body would tumble into the sun within less than 100,000 years.

That need not make us alarmed concerning the stability of our earth, however, the lecturer continued; for this effect varied inversely as the diameter of the body. There was a Doppler emission effect, as the whole solar system moved through the ether; its determination was beyond the lecturer's powers of calculation, and it would be neglected. But the Doppler reception effect could not be disregarded. The planets and comets moved in ellipses. When they were drawing nearer to the sun, the light pressure increased; when they were receding, it decreased. In the first case the gravitation pull was decreased; in the second (receding) case the pull was increased. The resultant effect was always a resistance to change of distance, tending to make the orbits less elliptical.

If we imagined a comet to consist of a cloud of particles of different sizes, the light pressure would exert a peculiar sorting action. The finer particles would be more hindered than the coarser; the coarser particles would thus go to the front, and the finer would follow as a tail. But, on the Doppler principle, the finer particles would further spiral in, and the components of the comet, which first of all traveled along an ellipse, would, after several hundred orbits, fill the whole ellipse, and the different particles would describe different orbits, and no longer appear to belong to the same system. Ultimately everything would end in the sun.

So far, the lecturer remarked, our observations had not been carried on long enough to confirm these arguments. Mr. H. C. Plummer had recently investigated, from this point of view, the motion of Encke's comet, which seemed to shorten its orbit of three and one-half years every revolution by about two hours; but he had not been able to explain this peculiarity on the light-pressure hypothesis. Yet some such effect must exist if comets had the constitution we ascribed to them. The zodiacal light might possibly be a remnant of dead comets.

Prof. Poynting concluded his interesting discourse with a "wild suggestion" referring back to Saturn. If we imagined that a big planet had, while still very hot, captured a cometary dust cloud, that cloud would spread out, the smaller particles would drop behind and spiral in; the larger particles would remain on the outer edge, and one or several rings might be formed; the rings would finally tend to become circular. Was that the origin of the rings of Saturn?—Engineering.

ELECTRICAL NOTES.

A new method of measuring the total quantity of Roentgen rays emitted in a given time, says Gaiffe in Comptes Rendus, is based on the fact that the fluorescent properties of substances such as barium platinocyanide are diminished or destroyed by the action of the rays. Upon the surface of the pastille of this substance which is exposed to the source, disks of a radio-active matter of varying transparency to the rays are placed, leaving part of the pastille unprotected. The unprotected portion becomes rapidly darkened, while the covered areas change more or less slowly according to the degree of transparency of the protecting substance. It remains then to calculate, by other methods, the different quantities of Roentgen rays which will reduce each of the several covered portions to the same degree of dullness as the unprotected area, the distance from the source being constant. With these data the operator can at a glance determine the quantity emitted at any time during a *séance* without interrupting the administration, and without removing the pastille in order to examine it by daylight.

G. W. Pierce, in Phys. Rev., gives the following description of the experiments conducted with the direct method of coupling (Braun's type, in which the condenser discharges through some of the turns of an inductance in the aerial circuit): The transmitter was adjusted until a maximum reading on a hot-wire ammeter between the aerial and ground was obtained, and various forms of receiving circuit were tried. First, the resonance curves were obtained with the receiver tuned by added inductance in series with the aerial. The curves are much more obtuse than was the case with inductive coupling, the deflection dropping to half for a decrease of 26 per cent, or increase of 60 per cent in the inductance in circuit for maximum deflection. This loss in sharpness of resonance is not accompanied by any great gain in intensity of signals, the deflections being only 1.4 times as great as those in the case giving a fall of energy to one half for a 5 per cent dissonance, with inductive coupling. The tuning is next effected by the use of a variable capacity in shunt to the oscillation galvanometer; and the relation between height of aerial and the resonant inductance and resonant shunt capacity in the two methods is examined. *Relation of integral current received to height of receiving aerial.*—Plotting deflections against height of aerial when the tuning is effected (1) by added inductance, and (2) by a shunt capacity, the curves obtained show that the latter method of tuning gives larger deflections; the advantage increases with increasing height, and in one case the deflections were as 3: 1. Replotting these curves with ordinates changed by a constant multiplier, the curve of the fourth roots of the deflections obtained by method (2) is a straight line, while that of the *square* roots of the deflections by method (1) is a straight line. So that if tuning is effected by method (1), i. e., added inductance, the current is proportional to the height of the aerial. If tuning is by method (2), i. e., capacity in shunt, the current is proportional to the *square* of the height of the aerial from the "effective ground." It is shown that the resonance conditions are not modified when the receiver is placed in shunt to part of the tuning inductance (equivalent to an inductive shunt to the instrument), but only the received energy is diminished. Experiments to test the image theory of the action of the ground are given in conclusion: good agreement with theoretical predictions. It is found that it is easy to balance the aerial at the receiver with an artificial ground which will increase the reception of energy 20 to 25 per cent over a good actual ground.

SCIENCE NOTES.

Experiments to determine the influence of the order of additions of steel upon its solubility in dilute sulphuric acid are described as follows by O. Bauer in Königl. Materialprüfungsamt, Mitt.: Alloys of steel containing approximately 0.3 per cent of carbon, with tungsten and aluminium, were prepared in two ways; in one case the steel was poured into a heated crucible containing both the tungsten and Al in a finely-divided state, while in the other the tungsten alone was placed in the empty crucible and the Al added on finally filling up the crucible, the amount of Al and tungsten used in both cases being the same. Small plates cut from the reguli found in each of the crucibles were exposed to dilute sulphuric acid (containing 1 per cent of acid) for a total period of 288 hours, and the loss of weight determined at intervals. In all cases the material produced by adding the Al separately was found to be dissolved more rapidly. This result is tentatively ascribed to the partial oxidation of the tungsten in its material.

Fusion possibilities in vegetative cells are more or less common in all groups of plants. In basidiomycetes parallel filaments fuse under many conditions of development, and a pseudoparenchymatous tissue may result. In grafting, the layers which fuse may represent different species or even different genera. Little is known concerning the factors influencing such fusions. Allusion may also be made to the fact that plasmodia of the same species of myxomycetes (at least when produced in nearly similar conditions) fuse with one another. It should be accurately determined if this is an inherent property of the same race or species only, and if this fusion tendency may be weakened or dissipated by diversity of conditions under which the plants may be grown. The solution of such problems with simple and rapidly culturable organisms may even throw some light upon the more complex problems of self sterility and prepotence (in the sense in which these terms are used horticulturally) in higher plants—phenomena which may not be explained with present information. It has been found that tomato and tobacco fruits are sometimes formed without pollination; and the same is true of other plants. In certain cucurbits the act of pollination seems to afford a stimulus for the development of the fruit, even the dead pollen serving to call forth this response. Under such circumstances it may well be that other chemical stimuli may produce the same effect. On the whole, there are no more interesting problems in physiology than those relating to pollination, the penetration of the pollen tube, and conditions of fertilization. Many phases of these problems have thus far been studied by gardeners and horticulturists alone.

M. Charles Moureu, of France, has been examining the gases of mineral springs in Europe. The present researches show the percentage composition of the gaseous mixtures taken from the mouth of the springs. In this case the rare gases, argon, helium, etc., are estimated together, and their *ensemble* forms the gaseous residue which is not absorbed by the reagents. M. Moureu gives a list of the analyses which he carried out by his method upon forty-three different mineral springs on the Continent. Most of these are in France, but some of the Belgian and Austrian springs were also examined. It is found from these results that the proportion of rare gases follows that of nitrogen, but on the contrary, it is inversely as that of carbonic acid, one or the other of these gases predominating in the different springs. For instance, the water of Eaux Bonnes has a percentage of 98.20 of nitrogen and contains 1.80 of rare gases, while the Mont Doré spring, having 99.39 of carbonic acid, has but 0.0061 of rare gases. In general, the proportion of rare gases is from 1 to 1.5 per cent of that of nitrogen. Some springs much exceed this amount. At Bourbon Lancy, for instance, we find 2.8 and 2.9 per cent, and at Maizières the proportion of rare gases reaches the exceptionally high figure of 6.35 per cent. Observing the total mixture of the rare gases by the spectroscope, we find the presence of argon in each of the forty-three springs examined, and that of helium in thirty-nine cases. In general, the main ray of helium ($\lambda = 587.6$) is at least as bright as the strongest rays of argon. In some cases, as at Chatel Guyon, Mont Doré, etc., this ray was much weaker, although still clearly visible. Four springs only gave an absence of helium by the spectroscope, or it is at least too small to be observed. M. Moureu points out that the above facts are in close relation to the radio-activity of springs. They give new data for the obscure problem of medicinal effects of springs and also have a bearing upon geological researches of the strata traversed by the springs.

ENGINEERING NOTES.

A statement issued by the Department of Commerce and Labor says that during the fiscal year just ended 1,463 merchant vessels were built in this country. They measured 421,744 gross register tons, compared with 1,301 vessels of 326,213 gross tons for 1905. Of the new tonnage, 384 vessels of 73,399 gross tons were unrigged barges and canalboats. The year's increase has been entirely in steel steamers on the Great Lakes, they numbering 52 and measuring 237,724 gross tons, compared with 29 vessels of 102,497 gross tons last year.

It is a fact of more than ordinary significance that a steam locomotive is capable of delivering a horse-power at the drawbar upon the consumption of but a trifle more than 2 pounds of coal per hour. This fact gives the locomotive high rank as a steam power plant. It is worthy of mention that the coal consumption per horse-power-hour developed at the drawbar by the different locomotives tested presents marked differences. Some of these are easily explained from a consideration of the characteristics of the locomotives involved. Where the data are not sufficient to permit the assignment of a definite cause, there can be no doubt but that an extension of the study already made will serve to reveal it.

W. Watson describes in the Automobile Club Journal some experiments with a comparatively slow-running two-cylinder four-cycle engine, throttle-governed with mechanically-operated inlet valves. The cylinder diameter was 88.9 millimeters, and the stroke 101.6 millimeters, the cranks being at 180 deg. The engine was coupled by means of a belt to an electric motor. Various indicator cards are included, these having been taken with a Hospitalier-Carpentier manograph. The results of experiments under various conditions are as follows:

	Horse-Power.	Ratio of Braking to Power, Per Cent.
Power delivered at clutch by engine when working	3.7	....
(1) Braking effect, throttle closed	1.23	33
(2) Braking effect, throttle closed, compression cocks open	1.69	46
(3) Braking effect, exhaust valve opened on No. 3 stroke	2.40	65
(4) Braking effect, exhaust valve prevented from opening	1.60	43

Thus the maximum braking effect which can be obtained at the clutch is 65 per cent of the power the engine is capable of giving at the clutch. If account were taken of the losses between the transmission gear and the road wheels, the percentage of the braking effect would be considerably increased, since this loss in transmission would decrease the power delivered by the engine, and increase the power absorbed when the engine acts as a brake. The advantage of employing the engine as a brake, over ordinary brakes, lies in the fact that the water-circulating system removes the heat generated, and prevents the burning up of brake leathers.

Water-Tube Boilers on War Vessels.—Aquatubular (water-tube) boilers are more generally taking the place of the old cylindrical generators, principally on men-of-war. It is claimed that they allow of higher speed, greater radius of action, and increased armament, in consequence of the possible diminution of weight. A dozen years ago only a few vessels of the French navy were furnished with these generators. To-day the total power of the aquatubular boilers of the different countries has reached a formidable figure—six and a half million horse-power. The Belleville boilers appear at present to be the ones most employed, although the German navy has tried them on only two cruisers and the United States on one. The apparatus is of two classes. One has large tubes, about 2 to 4 inches in diameter, and ¼ inch in thickness. For the others, the tubes are only 1¼ inches in diameter, with a thickness of ⅛ inch. The second class is used generally on torpedo boats, and vessels where everything else is sacrificed to speed. Among the twenty types at least of aquatubular generators, we may cite as apparatus having large tubes, of which many are French, the Allest, the Babcock & Wilcox, the Belleville, the Durr, the Niclausse, and the Yarrow. Among those of small tubes are the Blechynden, the Guyot, the Normand, the Reed, the Schulz, the Du Temple, the Thornycroft, and the Yarrow. England has many water-tube generators on large war vessels. They represent a total power of 1,721,000 horse-power and more, while the French scarcely exceed 1,076,000, though ours is not nearly as large as the English fleet. In the latter there are 937,000 horse-power in Belleville boilers, 193,000 in the Babcock & Wilcox, and 101,000 in Yarrow. For France we may put the figures at 385,000 horse-power in Belleville boilers, 217,800 in Niclausse, and 158,000 in Allest. In Germany, of a total of 443,000 horse-power, there are 151,000 Schulz, and 119,000 Durr. In the United States there is a marked predominance of the Babcock & Wilcox, 333,000 horse-power out of 494,000, and 41,000 Niclausse, and 34,000 Thornycroft. In Japan almost all the generators are the Belleville, 155,000 horse-power, then the Niclausse 28,000, out of a total of 186,000. The distribution is similar in Italy, where of 163,000 horse-power, 121,000 are represented by the Belleville boilers, and 28,000 by the Niclausse. Austria has 144,000 horse-power, of which 78,000 are the Yarrow, and 58,000 the Belleville. Of 1,780,000 horse-power of water-tube generators installed on torpedo boats and

torpedo-boat destroyers, 737,000 horse-power belong to Great Britain, 209,000 to France, and 200,000 to Germany.—La Nature.

TRADE NOTES AND FORMULÆ.

To Fasten Pieces of Ivory.—Melt together in equal parts gutta percha and ordinary pitch. Warm the pieces of ivory to be united when applied.—Science Pratique.

Incombustible Paint.—This is composed of 40 parts of pulverized asbestos, 10 parts of aluminate of soda, 10 parts of lime, and 30 parts of silicate of soda, with a colorant not resinous and the addition of the necessary water.—Chemische Revue.

New Explosive Substance.—The following is the Cracken preparation: Dissolve picric acid in glycerine, and neutralize with ammonium carbonate. Add infusorial earth, then an aqueous solution of potassium nitrate; boil the whole and add a little sulphur. The explosive should be kept dry.—Nouvelles Scientifiques.

Protection of Gilded Frames from Flies.—Flies soil gildings deplorably, particularly frames, and there is danger of injuring the gilding by rubbing with spirits of wine to remove the spots; so it is well as a preventive measure to apply a copal varnish to the gilding. It may afterward be cleaned freely without having to restore the varnish.—Moniteur de la Bijouterie et de l'Horlogerie.

Zinc White Cement.—This is given as a cement readily worked, not adhering to the knife and hardening in twelve hours. It is composed of 48 parts of powdered zinc white, 22 parts of polishing varnish, 2½ parts of drier, 14 parts of the composition known as "English dressing," then 13 parts of ferro-minium and ½ part of powdered lamp black. This product costs a little more by weight than white-lead cement, but this is compensated by the fact that it weighs less per equal volume.—La Nature.

Removing Oil Spots from Marble.—Saturate fuller's earth with a solution formed of a soap liniment, ammonia, and water in equal parts. Spread over the spots and use a flatiron sufficiently hot to heat through the whole mass. The moisture in the solution will be more or less evaporated, and, according as it is necessary, it should be saturated again. It should be kept in position for several hours, and may be renewed at the end of a few days.—Les Corps Gras Industriels.

Glue Hardening in Light.—The base is bichromate of potash or a similar substance. It will cause paper to adhere closely to walls and resist perfectly the influence of moisture. Dissolve 225 parts of fish glue in 360 parts of water, and allow it to soak for 12 hours; add, while stirring, 115 parts of gelatine soaked for two hours in an equivalent weight of cold water. Then pour into the mixture, while stirring energetically, 60 parts of potassium bichromate dissolved in 250 parts of nearly boiling water.—Technisches Centralblatt.

Paste for Cleaning Gloves.—Take 28 parts of mottled soap, rasp it and melt in four times its weight of hot water, add 15 parts of lemon oil, and work up with a sufficient quantity of powdered chalk, in order to secure a good consistency; or 25 parts of white soap may be taken and melted in the same way with 15 parts of water, stirring well. When the mixture is warm add 16 parts of a solution of chloride of soda and 1 part of liquid ammonia of 10 per cent. Spread on the gloves with a piece of flannel and rub evenly.—Nouvelles Scientifiques.

Bleaching of Gutta Percha.—Dissolve the gutta percha in 20 times its weight of boiling benzine and add good plaster, shaking from time to time. Leave at rest for a few days, so that the plaster may be precipitated, carrying off the impurities dissolved in the benzine. Introduce the remaining and clear liquid in small portions in a receiver containing a double volume of 90 per cent alcohol, agitating constantly. The gutta percha will be precipitated in a perfectly white, pasty mass. Expose this mass to the air, and in case of need, triturate it in a mortar.—Chimica Industriale.

White Ink.—Besides inks made with acids, which are capable of decoloring paper and which may differ according to the nature of the pigment of the paper on which the writing is to be done, white inks are in general true paints. They may be made by grinding zinc oxide fine on marble, and incorporating a mucilage made with gum tragacanth. The mixture should be made slightly more liquid, so that the paint may flow well from the pen when employed for writing. Add to the liquid a little oil of cloves to prevent mold, and shake the bottle containing the ink from time to time, in order that the coloring substance may remain in suspension.—Revue de la Papeterie.

Perfumes for Soap.—These perfumes may be employed in the proportion of about 15 grammes per kilogramme of soap, that is, in the proportion of 15 to 1,000. A perfume can be made with 2 parts of oil of rose geranium, ⅓ part of oil of patchouli, the same quantity of clove oil, 1 part of oil of lavender flowers, 1 part of oil of bergamot, and 1 part of oil of sandalwood. A more simple perfume is composed of 3 parts of oil of lavender flowers, the same quantity of oil of rose geranium, the same quantity of rosemary oil, and 1 part of carraway oil. Still another perfume is made of 8 parts of oil of lavender flowers, 4 parts of bergamot oil, 2 parts of sassafras oil, ⅓ part of cassia oil, and 2 parts of Peru balsam.—Les Corps Gras Industriels.

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TABLE OF CONTENTS.